RADIO NEWS

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AUGUST, 1943

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DEPARTMENTS

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FOR THE *Record*

BY THE EDITOR

THE acceptance of FM for post-war broadcast channels may be weakened by a newly perfected "static eliminator" now being used by our Army and Navy to combat all types of man-made interferences and the noises created by lightning.

FM receivers were accepted in recent years largely because of their ability to receive programs in noisy areas clearly and without static and other disturbances. The other selling point was that the audio-frequency range would include the full treble and bass frequencies as they appear at the original source in the studio.

If this new static eliminator becomes highly perfected, and we believe that it will, it will in large measure affect the sale of FM receivers where the customer is chiefly interested in listening to his programs without disturbing noises coming through his loud-speaker.

The regular broadcasters of AM will be able to keep the goodwill of their listeners, particularly in rural areas, if programs can be received that are free from static. The greater coverage of present AM transmitters is another selling point to consider. The static eliminator, developed by G. J. C. Andresen, Goodyear research physicist, was demonstrated by creating interference by means of spark coil close to the antenna of an ordinary radio set. Without the unit, the interference completely drowned out the program which was being received. The terrific interference reduced to a very slight buzz when the unit was switched in. Even a 25,000 volt spark from an airplane engine ignition system was effectively reduced to insignificance as far as its interference was concerned. This radionic unit has the ability to discriminate between static and the desired signals, and is capable of rapid automatic control of the amount of static on the same frequency as the incoming signal by permitting the energy of the static itself to generate a current of opposite electrical polarity. This in turn neutralizes the static.

(Continued on page 68)


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Spot Radio News

IN DEFENSE AND INDUSTRY

by LEWIS WINNER
RADIO NEWS Washington Correspondent

Presenting latest information on the Radio situation.

THE VITAL PART THAT RADIO is playing in Air Transport Service and will continue to play in the future, was revealed in a recent OWI report. According to the report there were 3,000,000 movements of aircraft handled by the Civil Aeronautics Authority traffic control centers in 1938. In 1942, these controlled movements rose to 6,000,000 while in 1943, it is expected that 13 to 14-million such movements will prevail over our airways. And by 1950, the CAA expects to control 60-million aircraft movements. This tremendous increase in traffic will demand an unprecedented provision for control via radio.

At the present time the CAA maintains and operates 408 intermediate-frequency radio range and marker stations, 197 ultra-high frequency radio fan markers and 72 ultra-high frequency radio range stations. The CAA predicts that in 1943 we will have 143 ultra-high frequency radio range stations. At present the CAA operates aircraft control towers at 74 designated fields, which are being increased to 120 or more this year. This is a far cry from the primary methods used in 1921, when the first night transcontinental mail flights took place, using bonfires prepared by obliging farmers as flight guides.

At present the Federal Airways Service operates six intercontinental superradio stations capable of communicating with aircraft at any point on the globe. These stations are located not only within the continental limits of the United States but also in its possessions. They are now being used solely for the war effort to provide weather and navigation information. Their combined range is so great that they can blanket the world and contact planes in flight anywhere on the globe. And this network is being increased to include stations in South America, Africa, Europe, Asia and Australia.

Ultra-high frequencies are seen by the CAA to be an important factor in solving the postwar airway problem. They say that ultra-high frequencies will eliminate static and provide a visual as well as an aural course, if not omnidirectional courses. Other innovations of the proposed postwar plan will be, two voice channels on every radio range station, the employment of ultra-high frequency for traffic control, ultra-high-frequency localizers for all important airports with glide path, and ultra-high frequency markers to permit the pilot to land under instrument conditions.

It is interesting to note that since 1927 the Civil Airways of the United States have increased more than 700%. For now there are over 35,000 miles of civil airways. It is also interesting to note that although only three years ago the CAA put into operation the first fully developed instrument landing system in Indianapolis, there are now many such systems in operation. And before the close of the year many more will be in operation.

Radio is truly a great friend of the airplane, and as time goes on its relationship becomes closer.

THAT SUPERSTATION OWNED by Powell Crosley, which had been the center of controversy for many years both in Congress and in technical circles, has now been recognized as a necessary factor. Authority has been given to reactivate this station and install additional transmitters, providing a total power of 750,000 watts. These stations will operate on shortwaves and be directed towards the Axis countries. This new powerful setup should really raise havoc in Italy, Germany and Japan and other Axis countries.

For years this Crosley station operating under an experimental license and with an output of 500,000 watts was the brunt of criticism in many circles. In Washington this authorization of power was criticized as concentrating too much power, in a political and technical way, at one point. Technical groups did not feel that this wattage was absolutely essential in the Cincinnati area. The fact that this power did permit coverage of areas not within reach of broadcasts by other stations, added weight, however, to the necessity of super power in the Middle West. And undoubtedly, at the conclusion of the war, super power will become a vital factor in many areas that cannot be covered with ordinary type transmitters.

FEAR THAT RADIO PRODUCTION was on a decline was dispelled recently when a Dow Jones report made its appearance. According to this report radio manufacturing companies have an estimated 6-billion dol-


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lar backlog of war orders on their books or enough business to keep them going for a year and a half, based on the current production rate.

There has been some reshuffling of manufacturing activities due to revised military requirements, but the overall production rate has not diminished. And according to present indications there is very little likelihood that production will be decreased.

CONSOLES IN CANADA are rapidly becoming victims of the war. While consoles have not been manufactured for quite awhile, they were available in substantial quantities in many cities. With, however, the increased income of the war worker and his inability to buy table model receivers, the consoles became quite popular. According to a recent survey most stores will be unable to supply consoles the latter part of this year. There are some dealers that will be able to supply these larger type radios, but little sales effort will be made to get them off the floor.

While all plants in Canada are working on war projects only, there is a possibility that allotments of material will be made to provide for the production of table model receivers, similar to the victory type made in England.

Portable receivers have, of course, been the most tragic victims of the war, in view of the restrictions on battery production. The farmer, however, will probably be given the same consideration as the American farmer and be allowed to buy batteries for his radio, provided no other receiver is available. By the time that this data appears in print, undoubtedly the Canadian government will have authorized farm battery distribution.

Interviews with many of the large distributors in Canada seem to indicate that parts for maintenance are holding their own. Except for very rare instances, most of the replacement items needed are available. The greatest problem in repair work in Canada has its counterpart in the United States, too. And that is, manpower. It is estimated that almost two-thirds of those formerly available are now in the services. While every effort is being made to train men and women for this work, it is not possible to complete such schooling as rapidly as desired. Thus repair work is being subjected to the familiar bottleneck. Incidentally, some of the broadcasting stations have instituted repair programs similar to those of many American stations to ease this situation. Technicians in these stations have been repairing receivers and training help as rapidly as possible.

THE WHITE-WHEELER BILL that we discussed a few months ago, is now receiving more attention than ever, because of the Supreme Court decision providing the FCC with important powers. Various organizations including the National Association of Broadcasters are making every effort to secure a prompt hearing and enactment of the bill which provides for a revision of the Communications Act.

At a recent NAB meeting, Senator Burton K. Wheeler, chairman of the Interstate Commerce Committee appeared to discuss the proposed bill. He said that every effort will be made to give serious and careful consideration to the proposed legislation.

Another proposed bill with technical aspects, that is not, however, in complete favor with the industry, is the Kilgore-Patman Bill. This bill which provides for the establishment of an office of Scientific and Technical Mobilization has been criticized by many as being inimical to the best interests of scientific and technical progress. Outstanding in this opposition is the Institute of Radio Engineers. They have adopted a resolution stating that the technical resources and particularly the radio facilities of the nation are now operating very efficiently in the war effort, and that accordingly the proposed legislation would result in utter confusion.

Still another bill which seems to be in the midst of controversy is the Bankhead Bill, calling for the expenditure of between 25 and 30-million dollars for advertising. The general feeling is that the radio industry should not accept government funds for advertising. However, if the legislation should reach the passing stage, the industry will insist that there be no discrimination between press and radio or other media of communication.

A NAB resolution stating the discrimination view was adopted recently and will be directed to the factors holding hearings on the measure.

Radio seems to have given Congress a bit of pondering to do.

NEWS THAT WILL GLADDEN ALL AMATEURS has been released by the FCC. They have reinstated all amateur radio operator licenses which expired on December 7, 1941 and since then. These licenses have been extended for a period of three years from the date of expiration, shown on each license. In the same order, known as General Order 115, the Commission has provided that all amateur operator licenses expiring between May 25, 1943 and December 7, 1944 will be extended for a period of three years beyond the expiration date on each license.

This new order was issued because the FCC felt that it was difficult for amateur operators who are in the armed services or engaged in war work at distant locations, to apply for timely applications for renewals. Of course these provisions do not apply to any operator who has voluntarily surrendered his license or to one whose license has been or may be suspended by FCC action. The order also does not apply to any amateur operator licensee who has failed to comply with the FCC order regarding citizenship. All stations are, of course, still prohibited from operation, but the Commission is still issuing new licenses and renewing those expiring now.

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THAT ORDER PROHIBITING RETAIL DELIVERY OF RADIOS fortunately has been rescinded in part. In the original order issued by the ODT, retail dealers were prohibited from delivering radios and phonographs. The wholesale delivery of radios and phonographs was permitted with two deliveries a week, but the dealers were unable to deliver the merchandise that they had received. This fallacy has now been corrected so that twice a week deliveries of phonographs and radios are now permitted, a fortunate ruling that has eased many an economic problem. The only problem now is to get all the radios that people would like to have for delivery. That, of course, is a condition which cannot be adjusted so easily in the present emergency.

POSTWAR PLANNING OR CRYSTAL GAZING has been a topic of comment at conferences and meetings, from coast to coast. And as the weeks go by, the interest on this subject seems to be spreading. All the analysis indicate that we will not have receivers of *out-of-the-world* style, as soon as the war is over. As a matter of fact, quite a few months will pass before we even have receivers from any plants because of conversion problems. And receivers made then will be similar to those made when production was stopped last year. There is talk in Washington that some materials for development purposes on peace time receivers may be available next fall. An allotment of this nature will, of course, provide for an earlier return of receivers when peace time comes.

The postwar planning ideas of most manufacturers have become practical, down-to-earth arrangements. Of course, there are many problems concerning distribution and tastes that cannot be answered or predicated now. However, all surveys do show that the need for new equipment will be vast. And it will take solid management and control to achieve complete success in this postwar era.

When the developments of the present war are employed in the postwar equipment, there is no doubt that we will have receivers that will be outstanding in every respect.

A NEW OVERALL GENERAL SCHEDULING order known as M293 covering *critical common components* recently went into effect. In this order *test equipment* has been included. From now on, all orders for test equipment must be accompanied by a new form as PD556 which is, in effect, another version of the old PD1A. This is an application form which the prospective buyer must send to the Radio and Radar Division of WPB for approval. One copy of the form is sent to the supplier with the order.

The test equipments included in the new order are included in eight groups as follows: In the first group we have audio and radio frequency signal generators and oscillators. In the second group are included frequency measuring equipment such as primary and secondary standards and associated measuring equipment, interpolation oscillators, heterodyne detectors, audio frequency meters, electronic frequency meters, electronic deviation meters, wavemeters and wave analyzers. In the third group are included harmonic analyzers and cathode-ray oscilloscopes. Electronic power supplies and voltage regulators (but not including variable controls) are included in the fourth section. The fifth group includes impedance bridges, wheatstone bridges, capacitance bridges, precision condensers, vacuum-tube bridges, inductance bridges, megohm bridges and megohmmeters, vacuum-tube voltmeters, electronic tube-testers, output meters, Q-meters, electronic volt ohmmeters, volt-ohm milliampere analyzers and noise and field strength meters. The other groups include precision standards, electronic speed regulating measuring equipment, such as stroboscopic devices, and oscillograph recorders.

AN INCREASE OF TEN PER CENT IN PRODUCTION is now expected because of the standardization of indicating instruments for the military radio and radar. The elimination of the wide variety of meters previously used, and the substitution of comparatively few types to afford the same results as the many types used before, will provide, of course, for simplified assembly and design.

Standardization has also been put into effect in other component groups, to further assist in the increased production quotas set by the Government.

POWERFUL AMERICAN-MADE BROADCAST stations operating on foreign shores are now blanketing the European and Asiatic continents. The latest transmitter to go on the air over there is the 50,000-watt station located in the heart of Belgium's African empire, Leopoldville. Its broadcasts are beamed primarily at Belgium. In Brazzaville, French Equatorial Africa, another 50,000-watt station is being built. This will carry the voice of Free France, direct to France.

These new transmitters are not makeshift units, but rather modern devices with such features as temperature and humidity control, air-conditioning, etc. Incidentally, these stations are also equipped for facsimile.

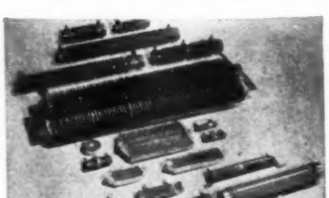
COPPER HAS BEEN PERMITTED to come out of its shell. Conservation order known as M9C was amended to provide for the use of copper in the production of radio receivers and parts, provided the manufacture of such products was permitted under the Limitation Order L265, released early last month. This metal, heretofore, had been restricted even for the use of repair parts. With this new ruling however, the necessary copper for repair parts and essential equipment is available once more.

RESISTORS IN THE AIR

In the new Bendix RTA-1B two-way telephone for aircraft and ground station service, WARD LEONARD, wire wound vitreous enamel resistors are used.

To quote from an article in March 1943 FM Magazine by Mr. R. B. Edwards, Bendix radio engineer, "Aircraft radio apparatus design might be described as the radio engineer's delight, for no restrictions are put upon the designer's ingenuity in using the best he can find in materials and methods to assure absolute dependability."

WARD LEONARD RESISTORS are built to withstand heat, moisture, vibration and other adverse operating conditions. The line covers a wide range of types, sizes, ratings, terminals, mountings and enclosures. Let us send you bulletins describing resistors of interest to you.



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Ward Leonard Engineers are at the service of every manufacturer of equipment using resistors. They will gladly suggest the resistor from the Ward Leonard line that will not only give you the best possible service but will be best adapted to the conditions of assembly.

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PORTABLE RADIO TRANSMITTERS have again distinguished themselves. Recently such a transmitter was dropped from a postal command plane to 19 survivors of a ship, torpedoed in the North Atlantic. This provided the means of contacting a rescue ship. This method of contact which occurred in Canadian waters was duplicated recently in American waters, except that in the American incident, the portable equipment was a part of a life raft. These unique transmitters employ a hand-driven generator to supply power. Transmitted are distress signals on international frequencies.

To provide effective coverage, box kites supporting an antenna and held aloft by glass yarn, have been used very effectively. These strands of glass yarn have proven their worth even under the most stringent conditions. It seems as if the yarn is not affected by salt water spray or other oceanic elements. Accordingly the kite is kept aloft, without fear of breakage, even in a storm-swept sea.

The Germans also use transmitters of this type for rescue work. However, their equipment is much larger and bulkier and according to tests, less effective in both coverage and consistency of performance.

THE MIDDLE WEST IS PLAYING a most important role in the manufacture of military radio and detection devices, according to a WPB statement covering the *Arsenals of America*. They say that 25% of the equipment used in radio and radar comes from Region six which consists of the states of Illinois, Wisconsin, Indiana and Iowa. Contracts in this region total over a billion dollars.

THE REPUBLIC OF MEXICO now has a chain of thirty-six stations which will be linked to the Mutual Broadcasting System. In the new service which will soon be in operation, both short wave transmission and long line telephony methods will be employed to effect international linking. The key station in Mexico City on broadcast frequencies is XEOY and the short wave component of this station is XEOI. The chain in Mexico is known as Radio Mil.

WIRE FAILURES STILL SEEM TO HAVE A HABIT of occurring at the most inopportune moments. Recently, during a coast-to-coast broadcast, a wire failure between Denver and Omaha interrupted transmission to the East for over an hour. Engineers point out that although line trouble is rare its occurrences are costly events and usually difficult to control. This is particularly true in the long stretches of land in the west. The use of ultra-high-frequency relay stations, it is claimed would serve to alleviate this condition in many instances. These stations, they say, can be of the automatic, unattended type used by many facilities. In some states the police departments have used these unattended remote transmitter systems for as long as two years, without any type of servicing. They claim that it is less expensive than the wire system and more efficient. In any event, the suggested use of these relay units further emphasizes the growing importance of ultra-high frequencies in a variety of services.

THE PATENT OFFICE HAS ALWAYS BEEN a lively place, and it is livelier than ever today with so many interesting issues being released. Recently, for instance, a unique radio beacon system using two non-directional antennas was patented by Frank G. Kear, a consulting engineer of Washington, D. C. This development, wherein the antennas are spaced a certain number of degrees apart, with each antenna being supplied with modulated radio-frequency energy through which the beacon system may be controlled, will be used by the Washington Institute of Technology, to whom Mr. Kear made the assignment.

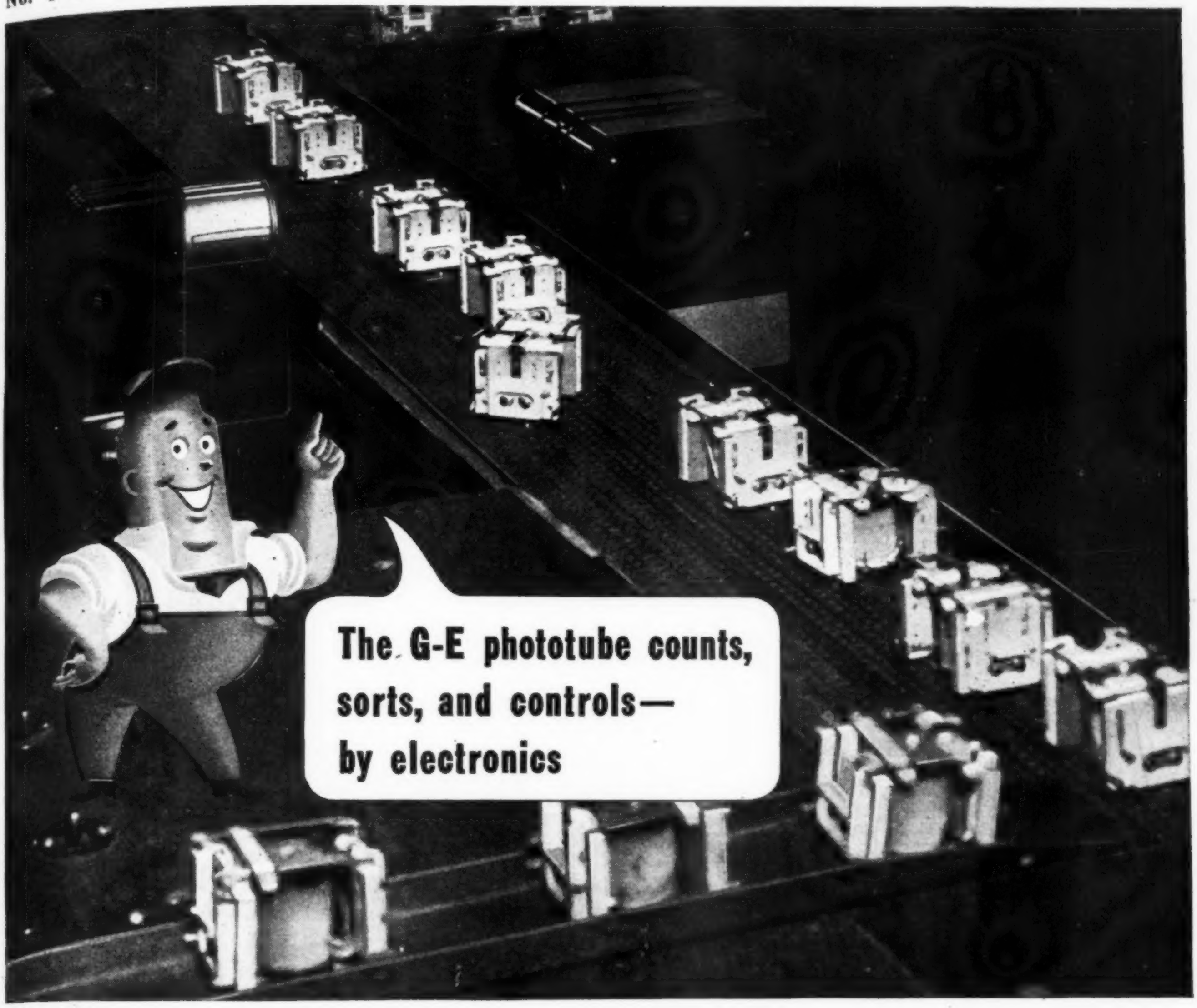
A cathode-ray indicator and a loop antenna mechanism, constitute the basis of another interesting patent that has just been granted. This cathode-ray and loop unit is used in a radio direction finder, and the patent was awarded to Henri G. Gusignies of New York. During the past months the cathode-ray has been a prominent feature of many patents. It appears as if this unusual tube will become the center of a great variety of detection devices that will not only be used for location purposes, but for servicing and maintenance studies.

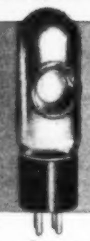
Two prominent men of the radio industry are also among recent patent winners. They are Dr. Ray H. Manson, who is vice-president and general manager of Stromberg-Carlson, and Albert E. Schell, an associate in the company. Their patent consists of an automatic phonograph record changer that operates with either ten- or twelve-inch records in series, or with the front and back of the records in succession. Work on this new device was started before the war. Production, of course, is being withheld until the conclusion of the present emergency.

While pouring over patent records we also ran across a patent that truly belongs to the . . . *believe-it-or-not* . . . class. According to the patent No. 877,357, Nathan Stubblefield, in 1902, developed a means of transmission of sound, music and the human voice, that appeared to be the basis of broadcasting. Experiments started in 1892, according to records. And on Decoration Day, 1902, Mr. Stubblefield held a demonstration using the equipment described in this patent and transmitting over a distance of a mile. The demonstration was made in Philadelphia between Belmont Mansion and Fairmount Park. Not only did Mr. Stubblefield win a patent in this country, but also in England and in Canada.

(*Continued on page* 90)

No. 4 OF A SERIES EXPLAINING THE USES OF ELECTRONIC TUBES IN INDUSTRY





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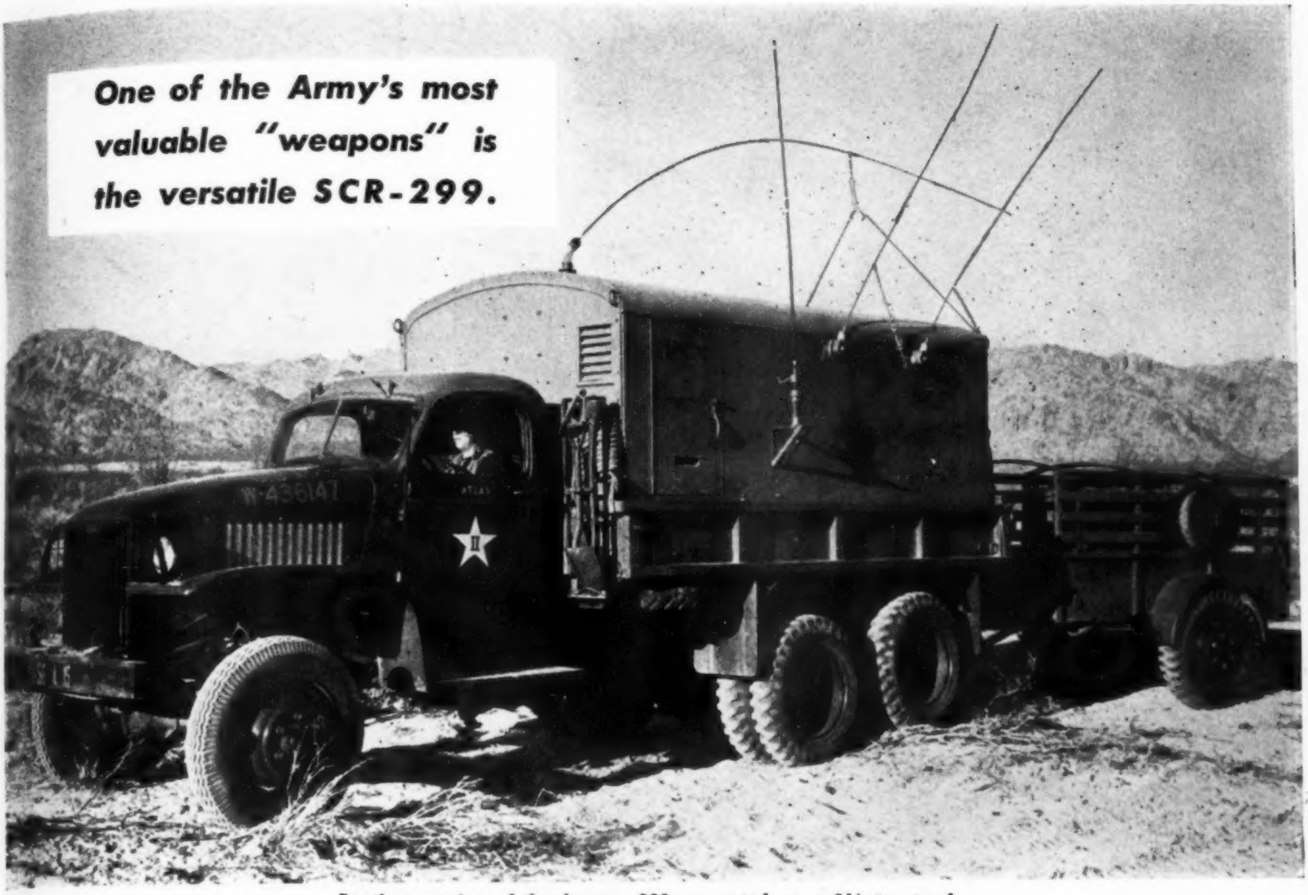

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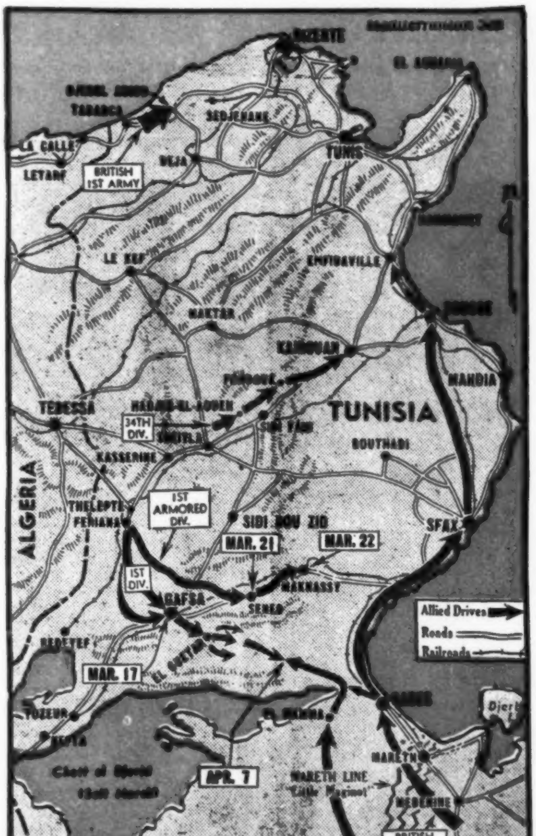
THE ARMY'S SCR-299

by OLIVER READ
Managing Editor, RADIO NEWS

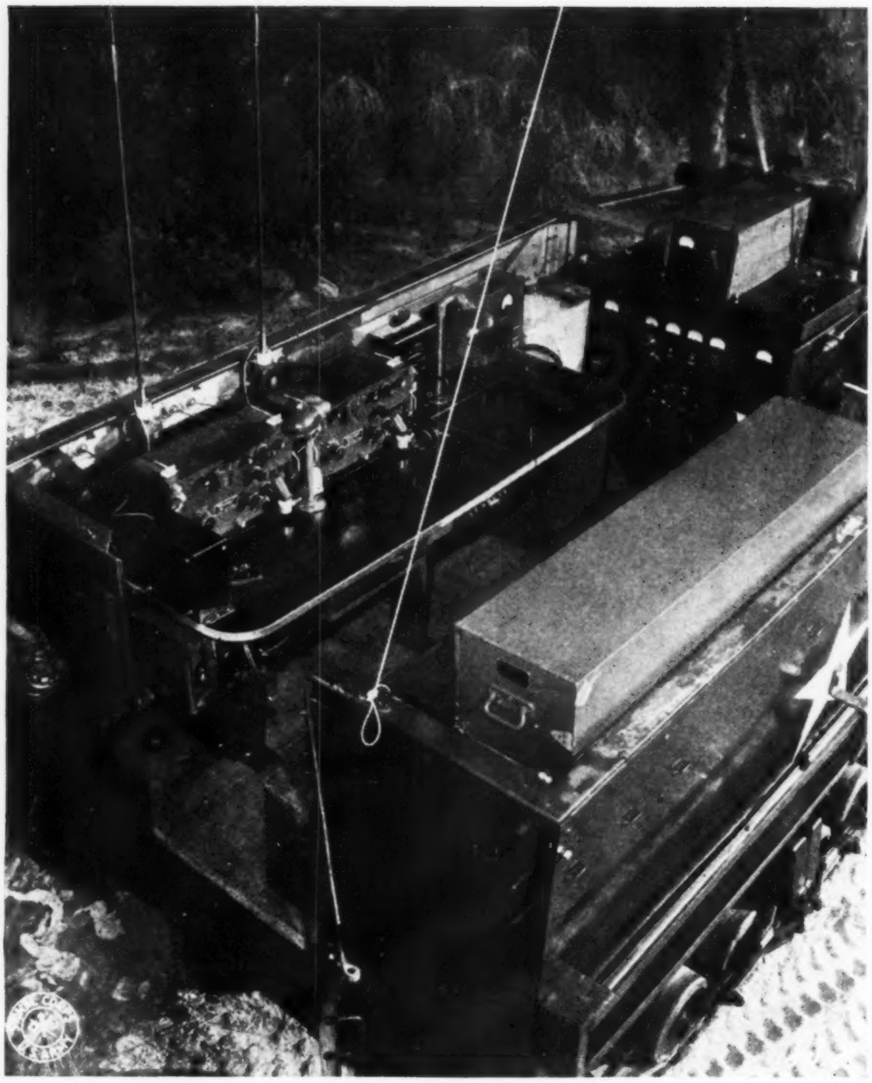
THE major contributing factors for winning a modern war include the development of secret weapons, new devices, or of an entirely new technique not possessed by our enemies. The Army, for example, has its Beaufors gun, its sensational Garand rifle, and its tiny, fast-moving Jeep. Our Air Force, with its Flying Fortresses and Liberators, has two outstanding combat weapons. The Navy, with its new radio locators and other detecting devices, has increased our defensive strength. And Signal Corps technicians in cooperation with civilian engineers have developed and produced many potent radionic weapons of war. One of the most outstanding in the latter category is the so-called SCR-299 mobile radio communications unit.

To the average layman, the Army has always followed certain development procedures and, in most cases, the final design of any particular product has been the result of out-moded techniques that had been perfectly adequate to handle any situation before modern "blitz" tactics were adopted. This story of the SCR-299 is a fine testimonial to American ingenuity and foresight, and to the Army's ability to utilize these qualities in securing their almost phenomenal successes in the "battle of communications."

Map below shows the territory over which the mobile units performed so efficiently.

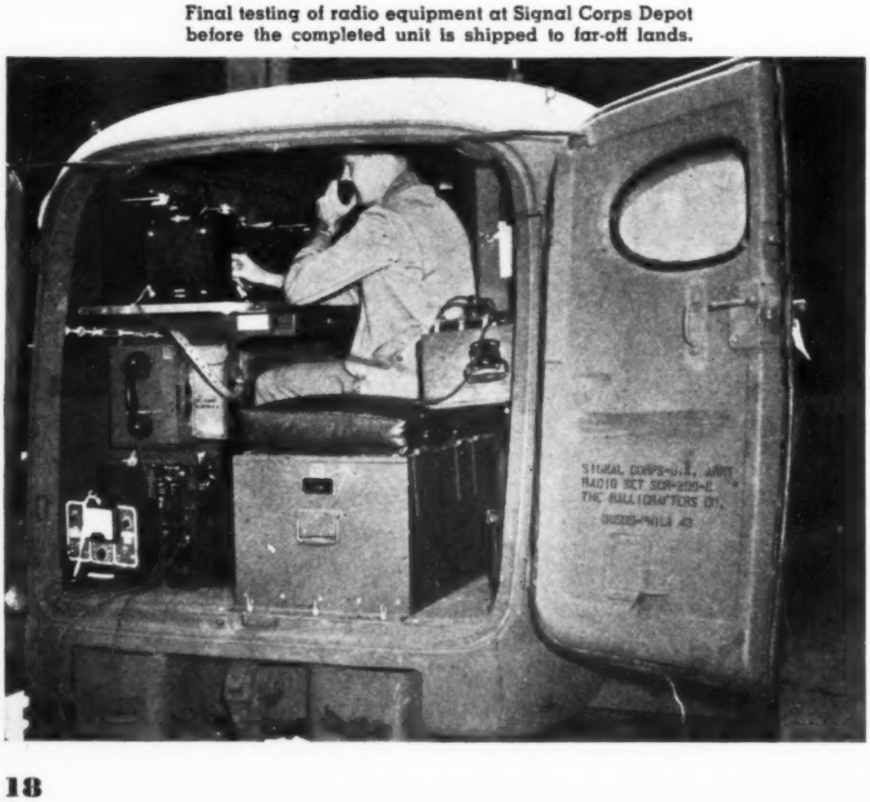


Courtesy—Chicago Tribune



A complete high power radio transmitter and receivers mounted in an Army M-3 Half Trac personnel carrier.

Final testing of radio equipment at Signal Corps Depot before the completed unit is shipped to far-off lands.



Interior of truck shows latest receivers and storage cases for spare tubes and coils.

The initial success of Germany's military machine was due largely to the rapidity in carrying out military operations and by complete coordination between all forces. Without radio communications, such lightning-like military operations would not have been possible. Modern warfare relies on speed! As the requirements for more rapid action are demanded, so, too, does the necessity for faster and more reliable communications exist. In addition, modern wars are fought with combined operations from various forces. Among these we find the ground, air, armored forces, etc. None can function effectively as a separate force. Each must rely upon the others to help gain the common objective in the shortest possible time and with a minimum loss of personnel.

American military leaders had the foresight, prior to the bombing of Pearl Harbor, to predict what was to come and to realize that the plans for more complete coordination must be carefully made so that American forces would not be left unprotected from lack of timed coordination with their supporting forces.

In order to train thousands of new troops for modern warfare, it was necessary that they be schooled in the new techniques required for fighting against those nations who had taken great pains to perfect their military machine and who had equipped their forces with new instruments of destruction.

The 1940 Louisiana Maneuvers were the "proving ground" for our Army to test out our recently adopted tactics and to find out whether or not they would be effective in combating

Special heavy-duty cables connect the mobile unit with the trailer that contains the gasoline-driven power unit.

our potential enemies. Incidentally, the German Army broke through the Maginot line while these maneuvers were in progress.

The "maneuvers" represented the first and extended application of long distance tactics which utilized the mobility of the newly organized armored forces. After observations by various commands, it became apparent, particularly to skilled communications men, that a radio set was urgently needed which would be capable of transmitting (by voice) up to and including 100 miles, and furthermore, that this would be required even while the fast-moving armored units were in motion at various speeds over rough roads, through woods, and over difficult terrain.

While communications in the main were adequate, it was apparent that something must be done to provide satisfactory radio communications in the new "blitz" warfare. Colonel Dawson Olmstead, Commandant, Signal Corps School, Fort Monmouth, New Jersey, who attended the 1940 maneuvers and was subsequently promoted to Major General and Chief Signal Officer, recognized the problem and proceeded to lay the plans which resulted in the development of the SCR-299. After a complete analysis of the situation, Colonel Olmstead recommended that a high-powered mobile transmitter be designed which would be fully capable of producing the desired results. He suggested, too, that little time should be spent in searching for such a unit. The problem would have to be met immediately in order that the Army be supplied with the most modern equipment that could be developed and which would be capable of meeting the stringent demands dictated by his observations at the 1940 Louisiana Maneuvers.

Captain Frank C. Meade, War Plans and Training Division, now Brigadier General Meade, Director, Signal Troops Division, forwarded recommendations in regards to Colonel Olmstead's "dream transmitter" to the Signal Corps Board concerning the development of a set having the characteristics outlined.

A project was set up as the result and an allotment was made to cover development of the set at the General Development Laboratories in Fort Monmouth. Major General Roger B. Colton, Chief of Signal Supply Services, then Director of the General Development Laboratories, immediately gathered together a total of some 20 transmitters from various manufacturers throughout the United States. Each was given a complete technical analysis, a performance test, and other "baptisms of fire" in order to find out whether or not any one of them would offer possibilities as a basic unit from which the final model could be perfected and one which would meet all the requirements recommended by Colonel Olmstead. One of the demands upon the transmitter was that it cover a wide range of frequencies and that its components be so designed that they would operate continuously over long periods of time.

Among the many transmitters tested was the *Hallicrafters* HT-4, a 450-watt unit designed primarily for amateur communications. It packed a healthy wallop on both voice and code and its other features indicated that here was an ideal unit to which certain refinements could be added and that with these additions, the result would be a transmitter capable of being adapted to military uses. The transmitter problem was solved! The SCR-299 also includes standard *Signal Corps* BC-342 and BC-312 receivers and type PE-95 gasoline engine driven generator made by *Onan*, together with many other components produced by American manufacturers. Radio men scattered over our world-wide fighting fronts know this set as the SCR-299, now in service wherever our troops fight.

The design of the mobile unit for housing the equipment presented some very interesting problems. Due to the heavy power requirements of the transmitter, it was necessary to provide an independent supply which would be capable of continuous operation in any climate or temperature. It was apparent immediately that a single truck would not be practical inasmuch as the gasoline-driven motorgenerator, would, of necessity, be in close proximity to the operating position which would present definite hazards to the safety of the truck's personnel. Furthermore, the mechanical noises and other disturbances generated would interfere seriously with radio communications. By designing a special trailer, it was possible to separate the two units and to distribute the weight which made for better maneuverability. By separating the two units and by connecting them with specially designed cables, it was feasible to use the SCR-299 for either a fixed station or a fast-moving mobile unit.

Generals Olmstead (center) and Meade (left) at the fighting front during the African campaign.

All units in the SCR-299 are tied down securely. Shock mountings are used to absorb mechanical vibrations and to protect delicate equipment from severe jarring which results when the truck is in motion over rough terrain.

Another problem which had to be met was that of loading up a mobile antenna at the frequencies used. There is only one practical type for use in a fast-moving vehicle; that is the "whip" antenna with its specially designed insulator. Unfortunately, there is a limit to the over-all length. Not only must it be capable of taking considerable abuse when traveling through wooded areas but its insulator and accompanying support must be able to absorb and give way to changes from its normal vertical position. The *Signal Corps* engineers devoted much research to the design of the supporting insulator. One of the requirements was that it withstand the full r.f. carrier power flowing to the antenna from the transmitter. Many types were tried before one was found which would stand up in any weather.

The mobile unit, in its final form, was given a very thorough test at the *Signal Corps Laboratories* before it was delivered to the Army. Its performance was remarkable! Not only would it cover the range required but considerably more. The various components stood up under severe abuse. It was now ready to join the "battle of communications!" General Olmstead's "dream" had come true!

The SCR-299 is used by our troops wherever they fight throughout the world. The "299" is seeing service in fixed station installations and in cases of emergency have communicated successfully over a distance of 2300 miles (UHF). Not only do the American forces find this unit to be capable of giving trouble-free service on any battle front but the British as well found them so satisfactory that they asked for a large quantity on Lend Lease sometime ago. As new uses were found for the SCR-299, the demand increased. The demand exceeded the supply.

Major General Dawson Olmstead, Chief Signal Officer, and Brigadier General F. C. Meade returned recently to this country after an extended trip to many of our far-flung fighting fronts. They found that our troops had a large number of 299's.

The North African victory is now glorious history and it is significant that radio played such an important part in bringing the campaign to a successful conclusion.

The first contact of the British 8th Army and the British 1st Army during the time when General Montgomery was proceeding from El Alamein toward Tripoli and Tunis and when the 1st Army under General Alexander was coming from the West, was carried out with the SCR-299 mobile unit according to reports of personnel in that theater.

General Olmstead has said that the 299 contributed greatly during the operation of the Battle of the Kasserine Pass. At that time the American forces were being hurled back a matter of some 160 miles from the Pass in North Africa. There was considerable disorder during this retreat. Great quantities of tanks, artillery and even 299's and other equipment and material were captured by the enemy. There was urgent need at this critical time to reassemble our troops in order to make a stand against the advancing enemy. There was need for immediate reinforcements and replacement of supplies. The going was tough. Our forces, scattered over hundreds of square miles found that the only means for calling in such help was by our new radio equipment. The mobility of the SCR-299 was the answer to the problem.

Among the many observations made by General Olmstead was that the 299 had proven itself to be a highly versatile unit, capable of performing under the most unusual exigencies.

It must have been gratifying to the General to find that the set which he had originally recommended to the Army was being requested for use by the *Air Forces.* They had discovered the mobile SCR-299 to be an ideal unit for them and one capable of handling the many communications required by their personnel. It can now be told that the 299 is being used not only by our ground forces but by the *American Air Forces,* the *British,* and probably the *French.*

During his visit, General Olmstead

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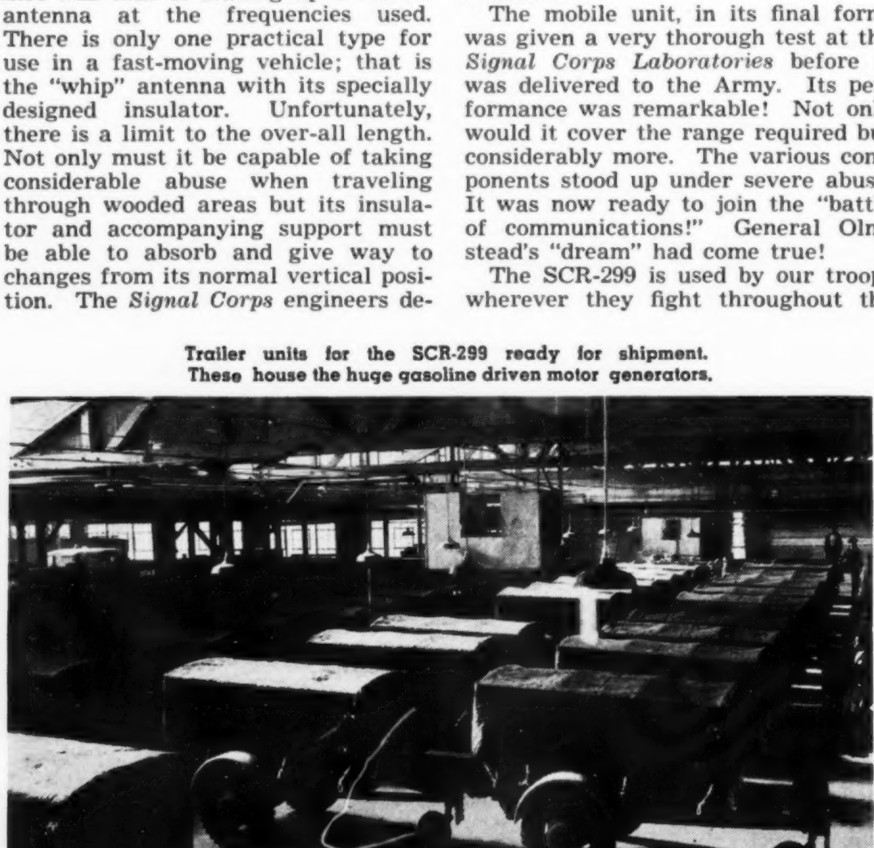
Trailer units for the SCR-299 ready for shipment. These house the huge gasoline driven motor generators.



Wide Band Amplifier Design

by EDWARD J. BUKSTEIN

The design of wide-band television amplifiers, covering a frequency range from 50 cycles to 5 megacycles.

FOR television applications and for other purposes which are today classified as military information, circuits are employed which will amplify uniformly a wide band of frequencies. The television amplifier, or video amplifier as it is often called, must fulfill two primary qualifications

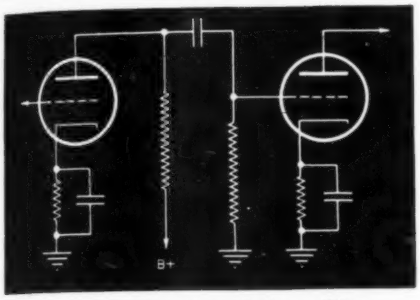


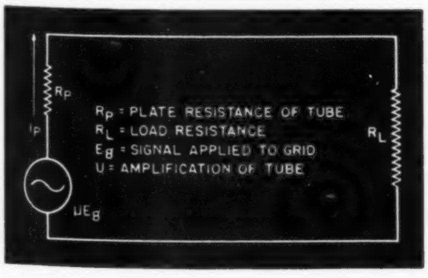
Fig. 1. Resistance-coupled amplifier.

not considered in the ordinary audio frequency amplifier. First, it must have a favorable gain characteristic for frequencies ranging from as low as 30 cycles per second up to four or five megacycles. The second requirement for the video amplifier is that it introduce no phase distortion. In an audio amplifier phase shift is relatively unimportant because the human ear is incapable of detecting it in the amounts present.

In the video amplifier, however, phase shift must be both dealt with and restricted, since phase distortion of the signal will result in a distorted image on the television screen. The time delay of the video amplifier must, therefore, be either zero or a constant over the entire range of its amplification. To understand fully the design considerations encountered in the video amplifier, one must first acquaint himself with the operation and shortcomings of the conventional resistance-coupled amplifier shown in Fig. 1.

For purposes of simplification of calculation, the circuit of Fig. 1 may be

Fig. 2. Equivalent circuit.



resolved into the equivalent circuit shown in Fig. 2. The tube here has been replaced by a generator developing a voltage of μe_g and having an internal resistance of R_p. The voltage developed by the generator causes a current, i_p, to flow through the circuit consisting of R_p and R_L in series. The value of the current, i_p, may be calculated by simple Ohm's law: $I = E/R$. The E in this case being μe_g, and R being R_p plus R_L in series.

Therefore, the current flow in the circuit of Fig. 2 is

$$i_p = \frac{\mu e_g}{R_p + R_L}$$

The voltage developed across the load resistance, R_L, is the calculation of most importance, since it is this voltage which is applied to the grid of the next stage. The voltage developed across R_L may be determined by again resorting to Ohm's law. The voltage is equal to current (i_p) times the resistance (R_L). Multiplying R_L by the equation already derived for i_p:

$$\text{Voltage across load} = E_{RL} = \frac{\mu e_g\ R_L}{R_p + R_L}$$

It is often advisable to rearrange this equation by dividing both the numerator and denominator by R_p:

$$E_{RL} = \frac{\mu e_g}{R_p} \bullet \frac{R_p\ R_L}{R_p + R_L}$$

Since $\dfrac{\mu}{R_p} = G_m$ or transconductance of the tube

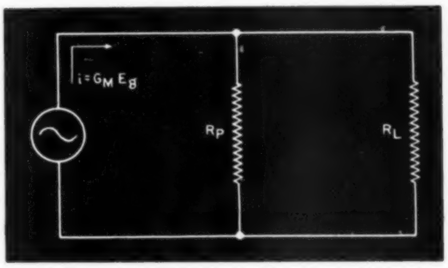


Fig. 3. Constant-current version of Fig. 1.

Then:

$$E_{RL} = G_m\ e_g\ \frac{R_p\ R_L}{R_p + R_L}$$

The calculations made thus far are based upon the equivalent circuit of Fig. 2. This equivalent circuit is known as the constant-voltage generator type and is most useful in making calculations where triodes are used. When pentodes are employed, however, another type of equivalent circuit is best suited to calculation.

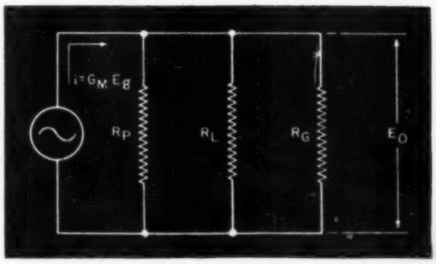


Fig. 4. Mid-band equivalent circuit.

This is the constant-current generator type and is shown in Fig. 3.

In this circuit the tube has been replaced by a generator which causes a current, $G_m\ e_g$, to flow through the plate resistance and the load resistance in parallel.

The action of an amplifier varies with frequency; therefore, to completely understand the operation of the amplifier, one must study its behavior in the different frequency ranges. These frequency ranges are divided into three groups: low frequency, intermediate frequency, and high frequency.

The equivalent circuit of an amplifier operating in the intermediate frequency range is shown in Fig. 4.

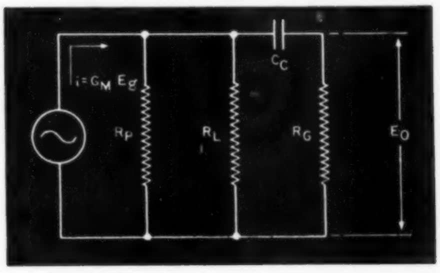
The plate resistance (R_p), the load resistance (R_L), and the grid resistance of the following stage (R_g) are paralleled across the generator supplying the current ($G_m\ e_g$). The amplified output voltage of the stage is e_o.

At the low frequencies the reactance of the coupling condenser increases and becomes appreciable. It must, therefore, be considered in the circuit analysis as shown in Fig. 5.

It is the reactance of the coupling condenser, C_c, which limits the low frequency response of the amplifier.

In the high frequency range, the reactance of C_c is very small and is therefore negligible. However, at the high frequencies, the shunt capacity

Fig. 5. Equivalent circuit for low-freq.



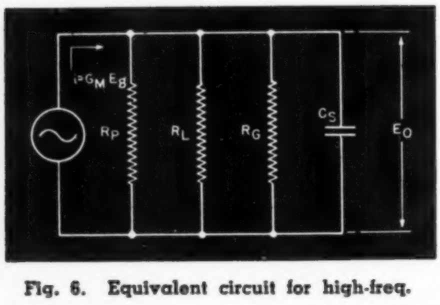


Fig. 6. Equivalent circuit for high-freq.

of the circuit must be considered (Fig. 6). This shunt capacity, C_s, is the sum of three individual capacities: the output capacity of the tube, the circuit wiring capacity, and the input capacity of the following tube. The reactance of C_s becomes very small at the high frequencies, and since it is shunted across the circuit that is in parallel with R_p, R_L and R_g, it tends to decrease the response at high frequencies, in the amplifier stage.

down to the level of the high frequency gain. Thus amplification is sacrificed to obtain a uniform frequency characteristic.

It can be proven mathematically that the amplifier's response, towards the higher frequency end, will be essentially flat (within 3 db.) up to frequencies of four or five megacycles if the following conditions exist. The value of the load resistor, R_L, should be equal to the reactance of the total shunt capacity at the highest frequency desired. The second requirement is that the inductive reactance, X_L, should be equal to one half of the load resistance, R_L.

Let us then proceed to design an amplifier to have a flat response up to five megacycles. Keep in mind that to obtain these results, R_L must equal X_{C_s} and that X_L should be equal to one half of R_L.

Suppose we design our amplifier using a 6AC7 tube followed by a 6AG7. These tubes are television pentodes having high transconductances.

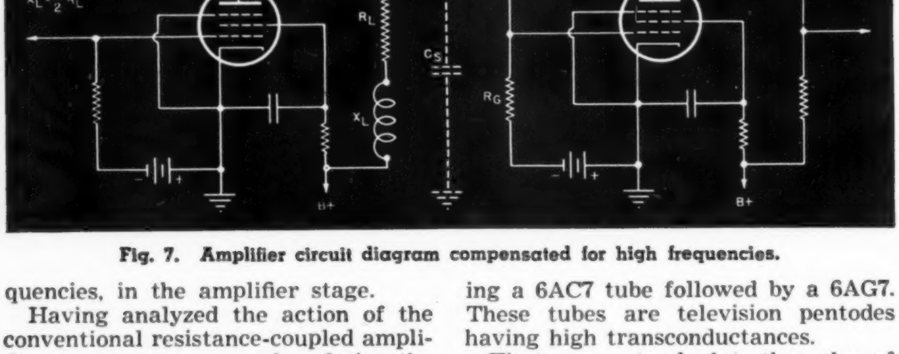


Fig. 7. Amplifier circuit diagram compensated for high frequencies.

Having analyzed the action of the conventional resistance-coupled amplifier, we can now proceed to design the video amplifier. By making compensations to overcome the faults of the amplifier, we can extend the range to include frequencies from 30 cycles per second to several megacycles.

To compensate for the dropping off at high frequencies, an inductance is inserted in series with the plate lead. The action of this inductance is to increase the load into which the tube works, as the frequency is increased. In this manner it counteracts the ill effects of the shunt capacity. This type of compensation is known as shunt peaking and is illustrated in Fig. 7.

The value of the plate load resistor used is usually quite small (less than 2500 ohms). By using this small value of load resistance, the gain at the intermediate frequencies is brought down to the level of the high frequency gain.

First we must calculate the value of the total shunt capacity of the circuit. The tube manual shows the output capacity of the 6AC7 to be 5 $\mu\mu$fd. The input capacity of the 6AG7 is 12.5 $\mu\mu$fd. We can estimate the value of the stray capacity of the wiring to be about 15 $\mu\mu$fd. Since these three capacities are in parallel across the circuit they are additive and their sum is 32.5 $\mu\mu$fd. By employment of the formula for capacitive reactance,

$$X_c = \frac{1}{6.28\,f\,C}$$

we find the reactance at five megacycles to be 980 ohms. Since the desirable condition is that R_L should equal this value of reactance, we know that R_L should be 980 ohms.

The second condition is that the inductive reactance, X_L should equal one half of R_L or 490 ohms. Working back from the formula

$$X_L = 6.28\,f\,L$$

$$490 = 6.28 \cdot 5 \cdot 10^6\,L$$

$$L = \frac{490}{6.28 \cdot 5 \cdot 10^6} = 15.6 \text{ microhenries.}$$

$\therefore$ 15.6 microhenries is the value of inductance required.

The gain of this stage may be calculated from the formula

$$\text{gain} = G_m R_L,$$

where G_m is the mutual conductance of the tube. In this case 9000 micromhos.

$$\text{gain} = 9000\ 10^{-6}\ 980 = 8.82$$

The loss of gain in an amplifier at low frequencies is caused by the increased reactance of the coupling condenser. Why not increase the capacity of this condenser then? The answer is that the capacity is limited by the maximum allowable leakage which is inherent in larger condensers.

To compensate for these losses, the value of the load impedance into which the tube works, must be increased at the lower frequencies. The method of doing this is illustrated in Figure 8. The reactance of C_f is increased with a decrease in frequency.

The conditions which must exist in order that the amplifier's response shall be flat to the lowest desired frequency are as follows. The reactance of C_f should be one-tenth or less of the value of R_f. Secondly, the values of the two time constants $R_L C_f$ and $C_c R_g$ should be equal.

To design the amplifier to have a flat response down to 50 cycles, we first decide upon a value for R_f. Assume 5000 ohms. Knowing that the reactance of C_f should be one-tenth of 5000 ohms at 50 cycles, we work back in the formula

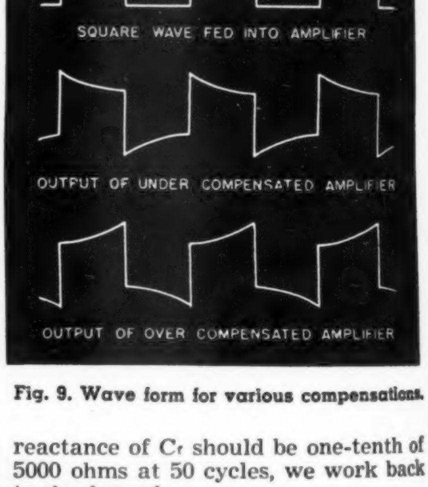


Fig. 9. Wave form for various compensations.

$$X_c = \frac{1}{6.28\,f\,C}$$

$$500 = \frac{1}{6.28 \cdot 50 \cdot C}$$

$$C = \frac{1}{6.28 \cdot 50 \cdot 500} = 6.37\ \mu\text{fd.}$$

6.37 μfd. is the value for C_f to give a flat response down to 50 cycles.

The second condition required is

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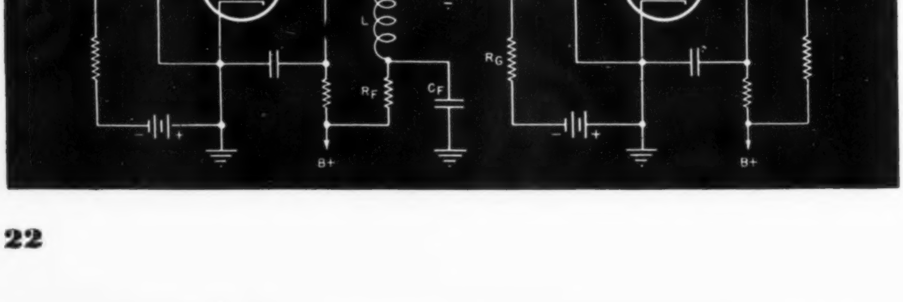
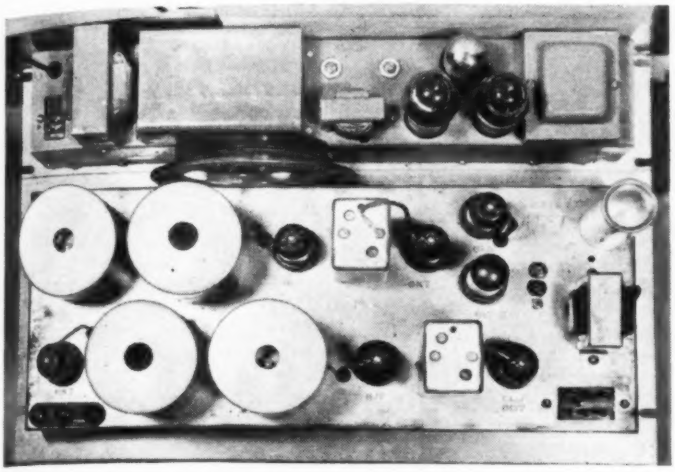
Fig. 8. Circuit diagram of an amplifier compensated for the low-frequency drop.



AIR-RAID Alarm Circuits



Top view of the Missouri State Highway Police alarm unit.

by
WILLARD D. STEWART

Alert alarms are vital for the protection of many of our coastal regions. Herein described are several proven designs used for civilian defense.

SINCE it is necessary to activate countless areas for air-raid warnings practically instantaneously, a swift medium of notification must be used. In radio, we have one of these lightning means of contact.

It has become the duty, therefore, of many types of transmitting stations, to maintain a constant listening watch for such warnings. Since it is impossible for the central air raid information supply source to reach all of these stations at once, a linking or network system must be used. Stations with wide coverage are used as key stations. These key units transmit a warning tone, when so notified. It is these warning tones that the other stations pick up, that completes the cycle of notification, and alerts the area. Since these notes, transmitted on the key station frequency, may come at any time, the listening-in post station must provide a constant watch. This can be done by either of two ways: a crew of operators or an automatic listener-in.

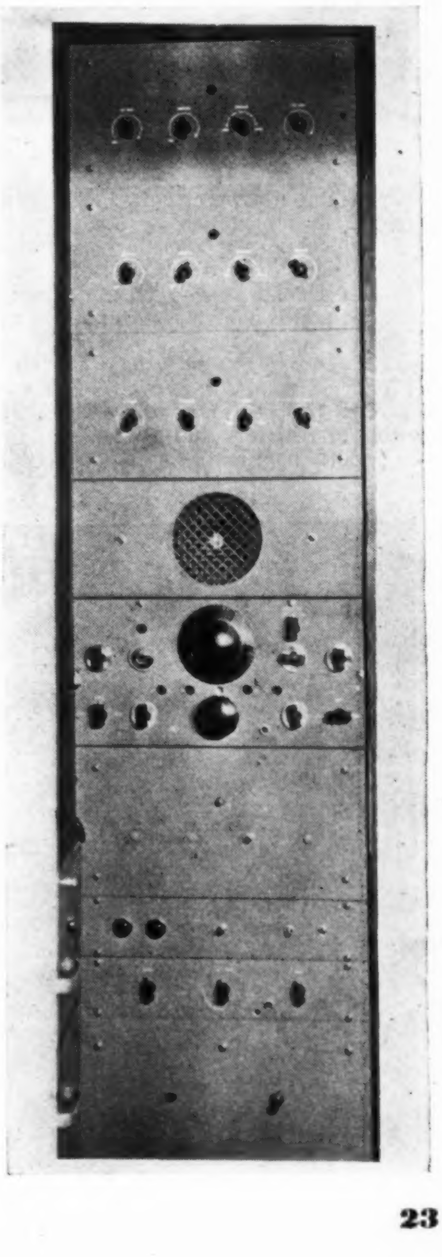
Many stations have selected the automatic operator or listener-in method, for it has proven not only to be very efficient, but a man-power saver. And both of these features are certainly essential today. While the automatic operator or listener-in takes many forms or circuits, its basic mode of operation is the same. For it is linked to the receiver and tuned to the key station frequency constantly. When the tone is picked up, an alarm is activated. Then the wheels of the air-raid warning service start flashing around.

The circuits used in these air raid alarms have a variety of interesting features of design. Incidentally, although these systems have been adopted for use in listening-in post stations, they can be applied to the receivers in the home, too.

Now, let us take a look at some of these circuits. All circuits have a basic purpose, as we mentioned previously. That is, they must respond to the warning tone. That means that none but the frequency of this tone must alert or actuate the circuit. It is in the means of actuating that most of the circuit variance exists.

In the unusually simple, yet effective alarm system, developed by Lieutenant Arthur H. Vickerson and Sergeant Robert L. Gray of the Boston Police, we find many interesting features. Relays are, of course, essential units in most alarm devices. We say most, for there are some that do not use the relay. This will be discussed later. In those alarms that do use the relay, the contacts of a relay may be connected to the output of a receiver. The contacts of this relay may then be made to energize the field of a second relay, using the voltage obtained from the "B" supply of the receiver. Across the winding of this second relay can be placed a large electrolytic condenser and resistor in series with each other. Then the contacts of this second relay can be used to turn on a speaker or a bell.

We obtain this result (Fig. 1A) because the normal output of a receiver is not continuous. Instead it varies according to modulation. Therefore the first relay has an opportunity to frequently come to rest on its back contact, recharging the condenser across the second relay. This, in turn, causes the armature of the second relay to remain energized, until a sustained tone arrives, which keeps the first relay from recharging the large condenser. Then the condenser discharges slowly through the resistor and the field of the second relay drops, releasing the armature which then



Panel layout of the fixed-tuned receiver and alarm system of the Missouri State Police.

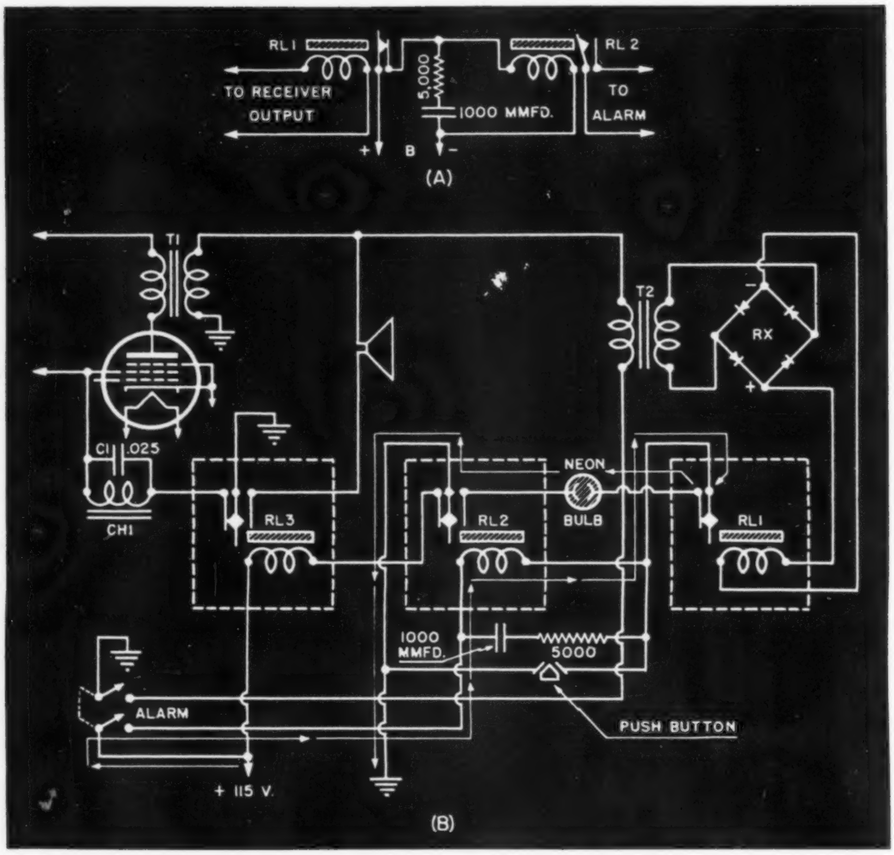


Fig. 1. The Vickerson-Gray alarm system with its basic circuit shown at the top.

closes the alarm circuit. The time period is determined by the capacity of the condenser and the resistor in series with the resistance of the field of the second relay. This condenser has an action which is similar to that of a storage battery. For circuit diagram refer to Figure 1(A).

It is necessary in actual practice to use the proper relays and the correct value of resistors and condensers, and in addition, arrange them so that maximum efficiency results. For, for instance, to obtain sufficient voltage to operate the first relay in the Vickerson-Gray system shown in Figure 1 (B), it was necessary to insert a step-up transformer T2, which is a plate-to-5-ohm voice coil transformer. And, instead of connecting it as usual, it was connected in reverse. To make the operation of this relay consistent, rectification was used. This was done by rectifying the output of the step-up transformer by means of a rectox unit. In this instance, this unit was obtained from an old battery charger.

The next problem concerned the exact frequency to which the circuit would respond. Thus it was necessary to devise a filter consisting of the audio choke Ch1 and condenser C1. In parallel with each other, they are connected to the screen grid of the output tube and to ground through the back contact of relay RL3. This relay is energized from the "B" supply of the receiver through the back contact of relay RL2. When the relay RL3 is de-energized, the filter combination is inserted or becomes activated. And all frequencies other than the warning tone are bypassed to ground. When the relay RL3 becomes actuated, the filter combination becomes inoperative, and the speaker is reinstated in the circuit through the front contact of the relay RL3.

To insure positive operation a ¼ watt neon lamp signal method is used. For, for instance, the neon will flicker when the warning tone is in the receiver output. In this way, it is possible to know when the receiver volume is high enough to insure positive operation and not too high to cause false alarms. The neon lamp is inserted in series with the energizing current being fed to the relay RL2. To reset the relay following receipt of an alarm, the push-button is used.

RL1 is a 2000 ohm relay; RL2 is a 5000 ohm relay and RL3 can be any type.

In this system, the warning tone is heard in the speaker. Thus it is necessary to turn the volume up so that it will be heard. That is why the neon lamp system is so important.

The system developed by Sergeant J. W. Bryant of the radio division of the Missouri State Highway Patrol, is somewhat along the lines of Vickerson-Gray system. In this alarm, the rectified audio operated relay is used to short the bias on the trigger tube, with the bias voltage being supplied by a 6H6 rectifying the 110 a.c. voltage. When the relay No. 1 is held open by a fifteen-second warning tone, the bias is permitted by the time delay circuit, to build up on the grid of the thyratron and cut off the plate current. Any sustained tone of less than fifteen seconds in length will permit the armature of this relay to drop back against the back contact, short the time delay condenser and force the time delay circuit to start from the beginning on the next tone (Fig. 2).

Through the time delay circuit (the 2 μfd.-7 megohm section), the ten or fifteen volts of bias supplied by the 6H6, is applied to the grid of the 2051 tube. When the back contact of the relay No. 1 is held open fifteen seconds, the bias builds up sufficiently to block the 2051 and the armature of the relay No. 2 is released. This disconnects the audio filter, connecting the speaker and breaking the plate feed to the 2051. By operating the push button, voltage is applied to the

Fig. 2. The alarm system developed by J. W. Bryant as used by the Missouri State Police.

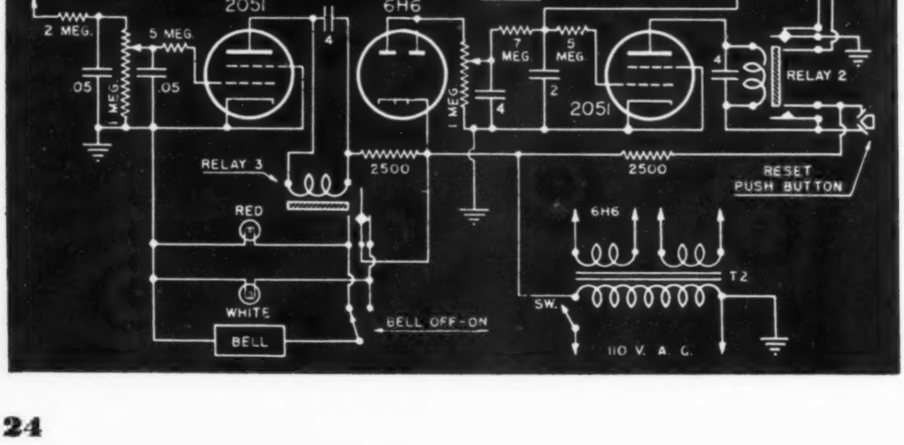


plate circuit of the 2051, restoring the unit to operating condition, or alarm-tone receiving condition.

Since it is always possible that the key station being listened to may have to go off the air, it becomes necessary to introduce some emergency system of warning. This is done, with what is known as a "carrier-off" alarm. Thus when the key station carrier leaves the air, the bias on the trigger tube drops to a low value, and the tube draws plate current, exciting the relay No. 3. This turns on the red signal lamp, turns off the white lamp, and energizes the alarm bell. This alarm may be discontinued by throwing the bell "on-off" switch to the "on" position. Then the operator can adjust the receiver to a frequency of another key station and maintain watch. If other stations are also off the air, the operator disconnects the silencing unit of the fixed tuned receiver and stands by on his key station (the key station originally assigned) for further instructions. When the key station returns, the relay No. 3 is relaxed and the bell "on-off" switch, being in the "on" position, causes the bell to ring. This indicates that the station is resuming service. The operator then listens for instructions, if the alert is still in effect.

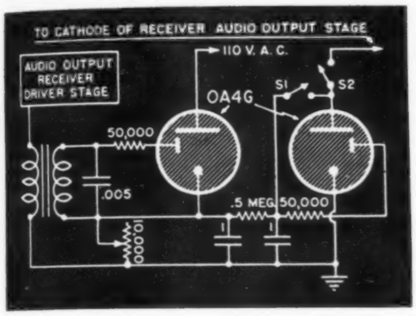


Fig. 4. An alarm system without relays.

Any type of relay with sufficient contact spring and resistances of 2500 to 5000 ohms can be used.

An air-raid alarm that uses a minimum of parts has been developed by Ramsey McDonald, supervisor of the police radio station in Richmond, Indiana. Only one relay is used in this system, and according to Mr. McDonald, almost any 115 volt a.c. type will do. He suggests that the tension spring be adjusted so that the relay will close on about .02 ampere and release on about .007 to .009 ampere. To determine what value of current should release the relay, it is necessary to check the plate current on the 43 tube, with the warning tone signal input on the 75 tube. The value of the current drawn after ten to fifteen seconds, should be the adjustment for the release on the relay (Fig. 3).

The 2 megohm variable control is quite critical, according to Mr. McDonald. Once this is set, you can use the volume controls of the receiver. If the controls are set too high, the relay will release on organ music. But by reducing either the 2-megohm variable control on the alarm or the volume control on the receiver just below this point, only the warning tone will be received. To be sure that the spring adjustment is set right, a milliameter in the plate circuit of the 43 should be used.

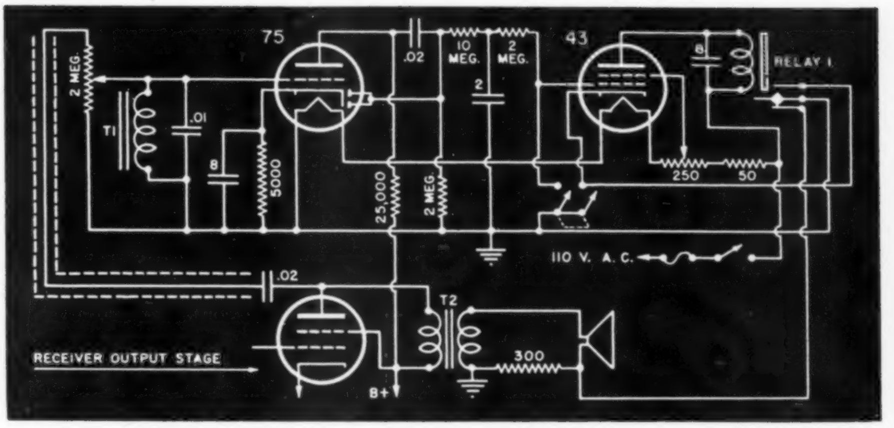


Fig. 3. The Ramsay McDonald air-raid alarm circuit as used by the Indiana State police.

By using another relay and a 43 circuit, a "carrier-off" circuit can easily be added to this system. Incidentally the operating voltage is obtained from the avc bus in the receiver. All values shown in the circuit have 400 volt ratings for the condensers and 1 watt for the resistors, except for the 250-ohm divider, which is a 25-watt affair. The 50-ohm resistor is a 10-watt unit. A 10-henry choke is shunted across the .01 μfd. condenser in the grid circuit of the 75.

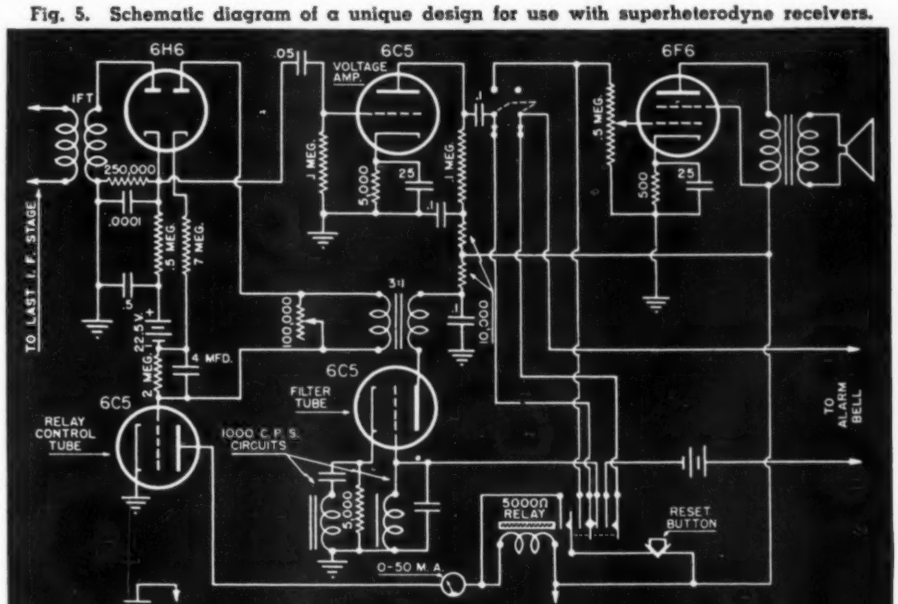
During our introductory remarks, we stated that while most alarm circuits used relays, there were some that did not. Here is one of those that does not use relays. It was developed by Ralph Hicks, supervisor of police radio at Tulsa, Oklahoma. The basis of the system has been designed around the operation of the cold cathode tube, the OA4G (Fig. 4).

In this alarm system, the incoming signal from the receiver passes through the single section filter to the control (trigger) starter anode of the first OA4G tube, which passes current only when the warning tone is applied to it. When the current starts to flow, the 1 μfd. condenser bridging the 10,000 ohm variable resistor, is charged positively at 70 volts, since the tube is also a rectifier. Then the 1 μfd. condenser in parallel to it, starts to charge through the ½ megohm resistor. When the voltage comes up to 60, the second OA4G tube triggers into operation and allows the last audio stage of the receiver to operate normally. This permits audible monitoring of the station. Since this second tube is between the cathode of the last audio tube and ground, there is a d.c. voltage across the tube. It does not cut itself off. But it must be shut off by momentarily opening the switch S2 to silence the speaker. This sets up the unit for warning tone receiving. The switch S1 is used to short out the control tube and permit normal operation of the monitor receiver.

While a sharper input filter than the plate-to-grid transformer and shunting condenser can be used, this one was found satisfactory. If more sections are used, care should be taken

(*Continued on page* 92)

Fig. 5. Schematic diagram of a unique design for use with superheterodyne receivers.



THE SAGA OF THE VACUUM TUBE

by GERALD F. J. TYNE

Research Engineer, N. Y.

Part 5. The era of controversy between patent rights on thermionic tubes designed by de Forest, Fleming, Weagant and others.

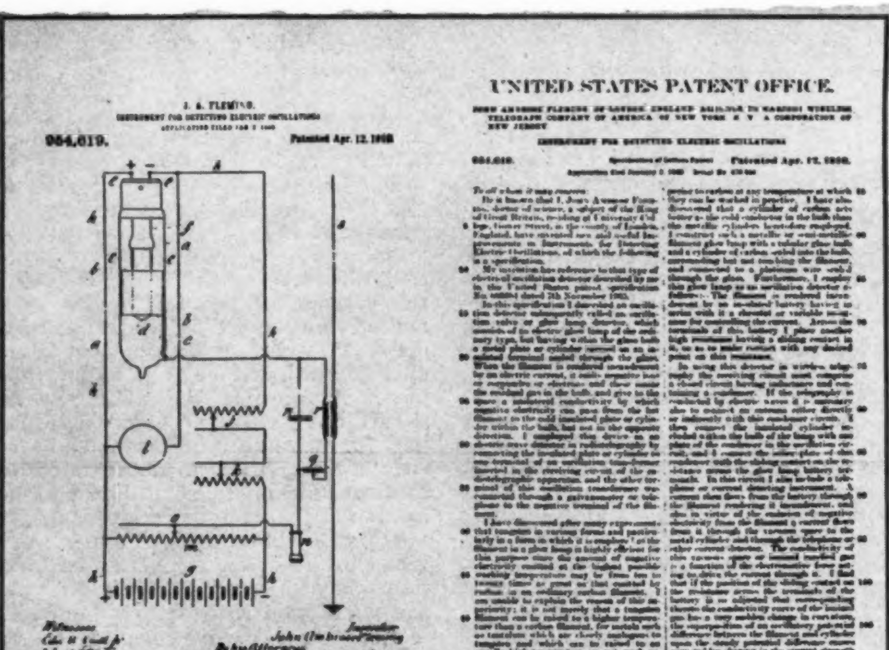


Figure 28.

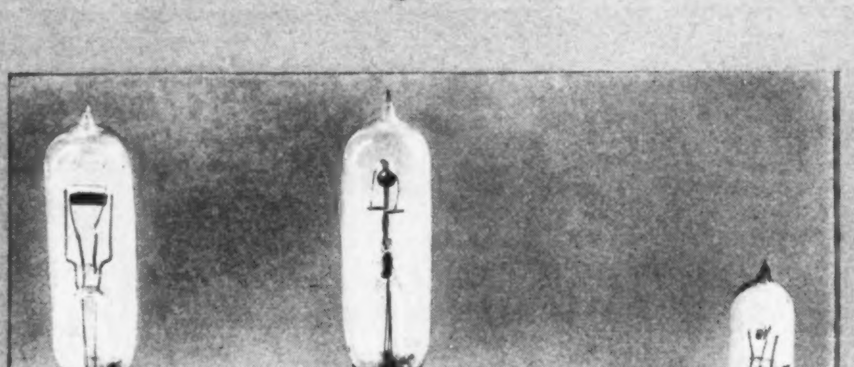


Figure 29.

AFTER the first applications of the valve to the rectification of high frequency oscillations, Fleming began to study their characteristics in detail. Some of the valves had filaments of tungsten. He determined the characteristics of the valves with varying plate potential, this plate potential being supplied by a separate battery which had its negative terminal connected to the negative terminal of the filament. He found that the curves were different with different filaments and different degrees of vacua. Analysis of the curves so obtained suggested to him another means of using the valve as a detector. If the plate potential could be adjusted to cause the valve to operate on the bottom bend of this characteristic, then the superimposed signal oscillation would produce a large change in the mean current through the vacuous space. This would mean an increase in the sensitiveness of the device as a detector.

Fleming applied on June 25, 1908, for a British patent on the use of an oscillation valve with a tungsten filament, and showed such a valve with the filament operated from a high voltage battery, using a large series resistance, and the plate potential adjustable by means of a potentiometer to obtain operation on the bend in the characteristic. The complete specification of this patent was accepted on April 15, 1909 and a corresponding United States patent was obtained in 1910.[112] (See Figure 28.)

This same bend in the characteristic had been shown by Fleming in his February, 1905, paper before the Royal Society, but no application of this phenomena was mentioned until the application for the above-mentioned British patent was filed. It is interesting to note that this application is equivalent to that described in de Forest's paper on the two-electrode Audion published in October, 1906, a year and a half before. The difference between them lay in the fact that de Forest used a separate battery to supply the plate potential, whereas Flem-

ing obtained the corresponding potentials by means of a potentiometer arrangement on the higher voltage filament battery.

Somewhat later, in a paper[113] by Dr. R. S. Willows and Mr. S. E. Hill, there were described experimental Fleming valves in which a Wehnelt oxide-coated cathode was used. Trouble was experienced in these valves with loss of coating from the heating wires. It is not known to the author whether or not any such tubes were ever used commercially.

In the court contest in the United States over the Fleming valve and the de Forest Audion, the attorneys for the Marconi Wireless Telegraph Company of America (the assignees of Fleming's U.S. patents) found it necessary, in order to make the patent stick, to disavow certain of the rectifier claims made in the original specification which were not limited to high frequency applications.

This was necessary because in the use of a thermionic device as a rectifier, the Fleming utilization was anticipated by the Wehnelt valve. Within these limitations the Fleming utilization patent for wireless detection was basic. In a practical sense it contributed little, if anything, to wireless telegraphy of that time. It was less sensitive than other known forms of detector, such as the electrolytic and crystal types, and never came into general use. What usefulness it might have had was soon overshadowed by the development of an electronic device of increased sensitiveness, the de Forest Audion, the first practical three electrode thermionic tube, which will be treated at length subsequently.

The Fleming valve enjoyed a brief revival during the early days of broadcasting in the United States, after the expiration of the Fleming patent. A number of types of diode were put on the market in this country at that time. Examples of these tubes are the "Dietzen Vacuum Tube,"[114] the "Electrad Diode,"[115] and the "Margo Detector,"[116] the latter two of which are shown in Figure 29. They had a rather short vogue, since they could neither regenerate nor amplify.

The development of the de Forest Audion led to a long and bitter controversy between Fleming and de Forest, and finally resulted in the famous Marconi-de Forest patent suit, of which more later.

While this suit was still unsettled the American Marconi Company, probably motivated by a desire to have available an alternative device in case the decision in the suit was unfavorable to them, began the development of a new tube. This work was done under the guidance of the late Roy A. Weagant, who was at that time chief engineer of the Marconi Wireless Telegraph Company of America. Weagant used a Fleming valve type tube and endeavored to obtain control of the electron stream by means of a third electrode which was placed outside of

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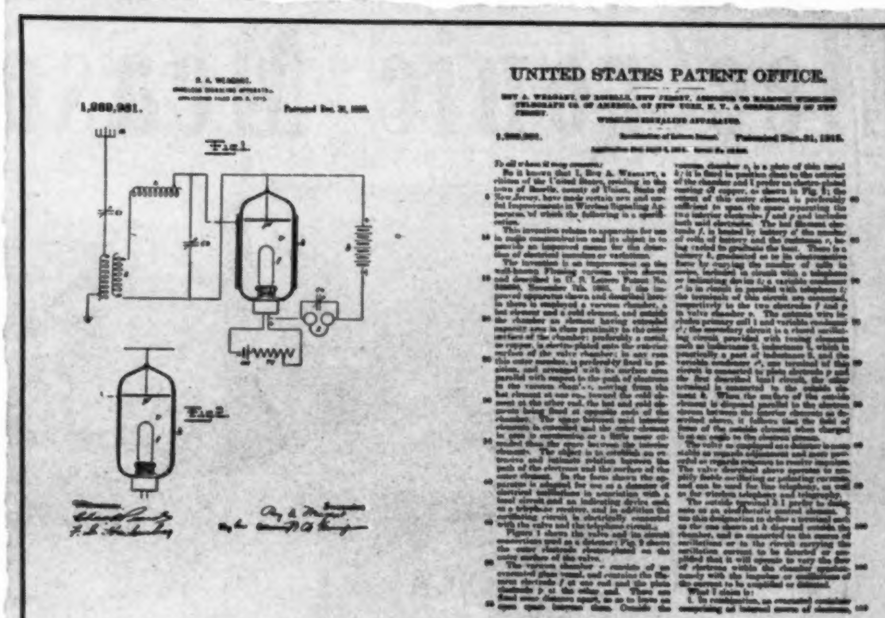


Figure 30.

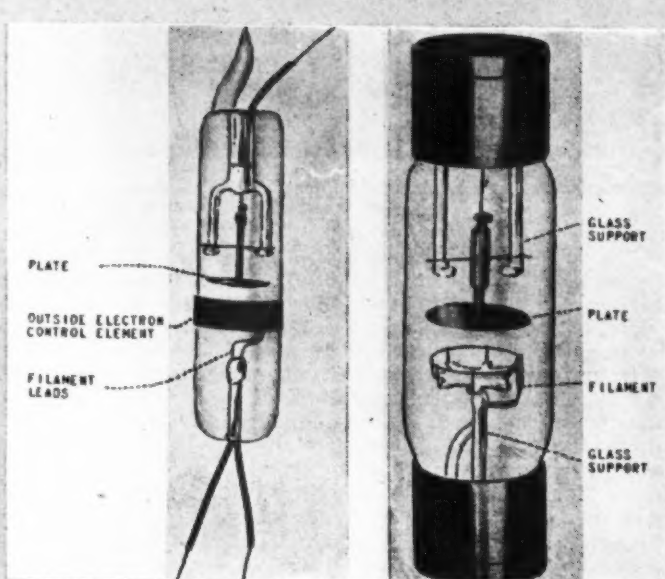
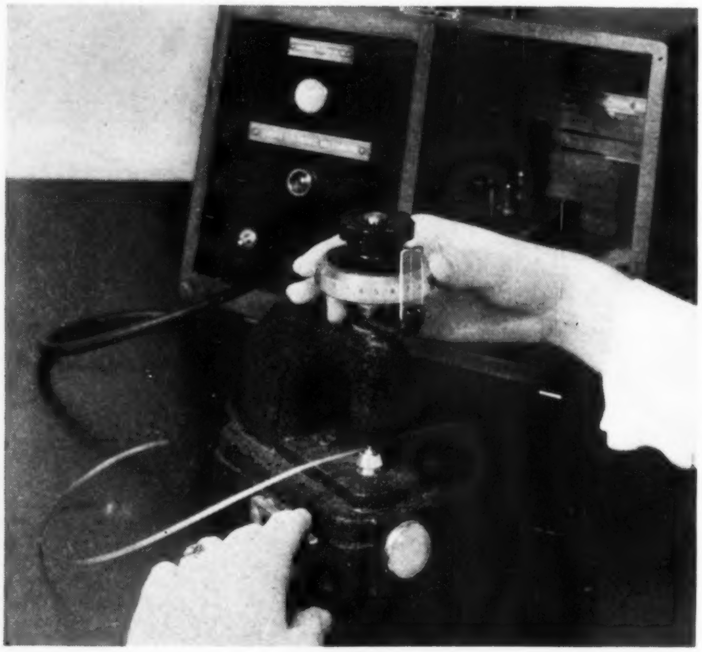


Figure 31.

Figure 32.

Figure 33.

Electronic Measurements



An electronic micrometer for checking thicknesses to .0001 inches.

by CLARK E. JACKSON

A resumé of circuits and devices for accurate and dependable electronic measurements in the industrial field.

☆

WHEN the scientific and industrial history of the twentieth century is written at some remote future date, one of the gleaming jewels of that saga will be the application of electronic devices to industry. Of this we may feel quite certain, since the introduction of finer tools has repeatedly marked the end of one industrial age and the beginning of a new era.

Aside from providing a variety of control mechanisms for production machinery and safety devices for machine operators, *electronics* has contributed an imposing group of measuring instruments which, in some cases at least, have already supplanted time-honored mechanical gauges. The march of applied science continues, indicating that ensuing developments will place many silent sentinels of accuracy along our production lines.

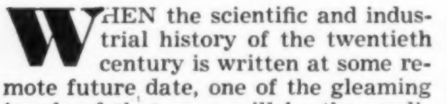


Fig. 1. Temperature measurements.

Electronic measuring instruments have been compelled to prove themselves to severe critics. This is partly because a great deal of this equipment has been fashioned around electron tubes and similar devices which, in industrial circles, have long suffered a reputation, undeserved in recent years, of delicacy and short-lived dependability. With increased ability to duplicate readings and to provide close accuracy under various stringent conditions of operation, however, electronic measuring instruments have become more firmly entrenched on many fronts.

High speeds of operation, surpassing the best of human records, have been attained by certain electronic indicators, and at the same time these devices have frequently proven themselves dependable and instantly available when needed.

Volumes have already been written on industrial electronic equipment. The number of available devices has been increased several fold in recent years. The country's patent literature abounds in information of this sort. Nor has the general public been neglected in the dissemination of this information. The man on the street, thanks to his liberal press, now knows that the edges of his razor blades may be inspected electronically with greater accuracy and speed than was possible with various mechanical gauges formerly employed for the purpose, although he may not comprehend exactly how it is done.

A few of these measurements are representative of those now being made in industries other than radio by means of electronic equipment. These, in turn, point to still other applications of the same methods and serve to stimulate productive imagination. Some of these measurements will be reviewed in this article, strictly from the informational point of view. Further, exhaustive data (technical or practical) on each topic may be obtained directly from various textbooks that may be purchased today.

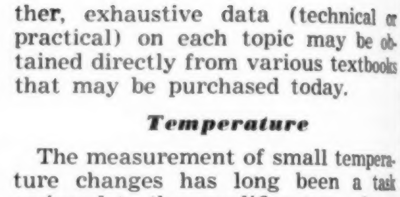
Temperature

The measurement of small temperature changes has long been a task assigned to the amplifier type of vacuum-tube voltmeter. Many temperature changes, hitherto not detectable with common thermometers or measurable only with very elaborate thermal apparatus, are now determined by this instrument.

Figure 1 shows a circuit arrangement for the measurement of minute temperature changes. The sensitive element is a thermocouple which is placed in contact with the device whose temperature is to be measured or is located within the space to be checked. Small changes in temperatures generate small currents in the thermocouple which are then amplified, by means of a high-gain d.c. amplifier, to actuate an electronic voltmeter.

There are several leading advantages of this arrangement for temperature indication: the amplifier

Fig. 2. Measuring light intensity.



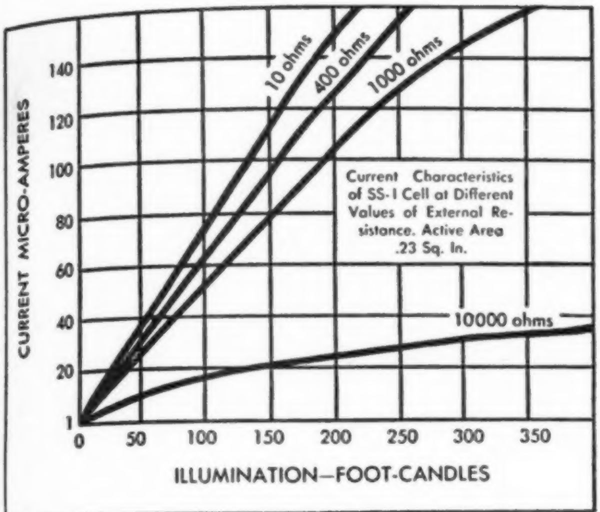


Figure 3.

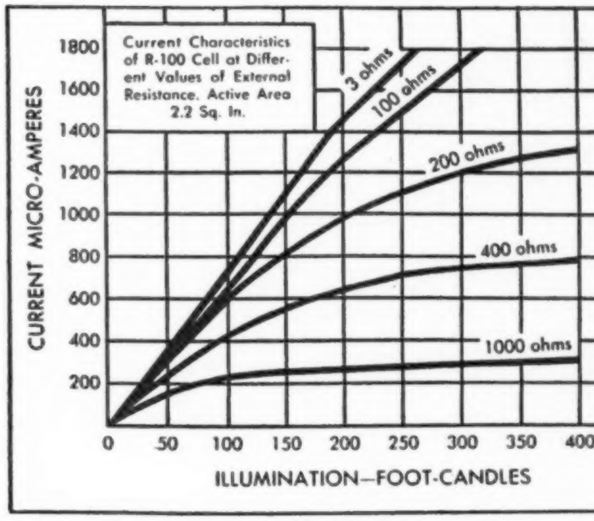


Figure 4.

permits the use of a voltage response meter with fairly high deflection values, thereby removing the instability and relative slowness of high-sensitivity galvanometers which might be actuated directly by the thermocouple. By its nature, the electronic voltmeter may be set to zero in the presence of an initial thermocouple current, a feature which permits this meter (the scale of which may be graduated directly in temperature units) to read *temperature differences*, starting either from room temperature or any initial instantaneous temperature level within the zero-set range of the voltmeter circuit. Also, there is no lag in indications, the instrument circuit responding instantly to variations in thermocouple temperature.

Considerable latitude in design is possible in the arrangement shown in Figure 1. For example, the design of the d.c. amplifier may be any of the conventional, well-known layouts for this stage of the instrument. Likewise, the electronic voltmeter circuit may be chosen in accordance with individual requirements from any one of the many suitable circuits now available. The entire set-up frequently is a combination of a standard d.c. amplifier connected to a standard, manufactured electronic voltmeter of suitable voltage range.

Similar arrangements have been employed in industry both to measure small temperature changes, small values of temperature, and to provide highly-sensitive thermostatic control. In certain chemical and biological laboratory processes, temperature changes amounting to a few hundredths of a degree are readily detected. Also, in electrical and physical research, instruments similar to the system shown in Figure 1 have found full acceptance.

When higher temperatures are to be measured, the amplifier gain may be reduced proportionately. When very high temperatures are to be measured, the amplifier may be dispensed with entirely, the electronic voltmeter serving as an indicator with high input impedance. An obvious advantage in the latter application is the fact that the temperature indicator may be placed at a considerable distance from the point of actual measurement, making it possible to maintain a constant watch from a remote point. An example of this application is the monitoring of temperature at a central supervisory point, of the furnace or oven temperature levels at particular internal points.

Illumination

Measurements of the actual amount of illumination generated by certain devices or materials, or of the illumination present at a particular point are of value in numerous instances. For example: illumination in correct amounts is essential to worker efficiency and eye health, and in determining the efficiency of lamps, reflectors, and other optical devices. The amount of light given off by certain materials is, likewise, a good indicator of the progress of certain processes.

For such measurements, there are available light meters of various types; illumination meters, color meters, foot-candle meters, exposure meters, etc. For simple, direct measurements, the simple light meter takes the form illustrated in Figure 2. In this arrangement, a self-generating photocell is connected directly to a sensitive d.c. microammeter so that currents generated by the action of light upon the cell will cause meter deflections proportional to the amount of light. The meter scale may accordingly be calibrated and graduated directly in light units to provide a direct-reading illumination instrument. This arrangement is employed in the popular exposure meters.

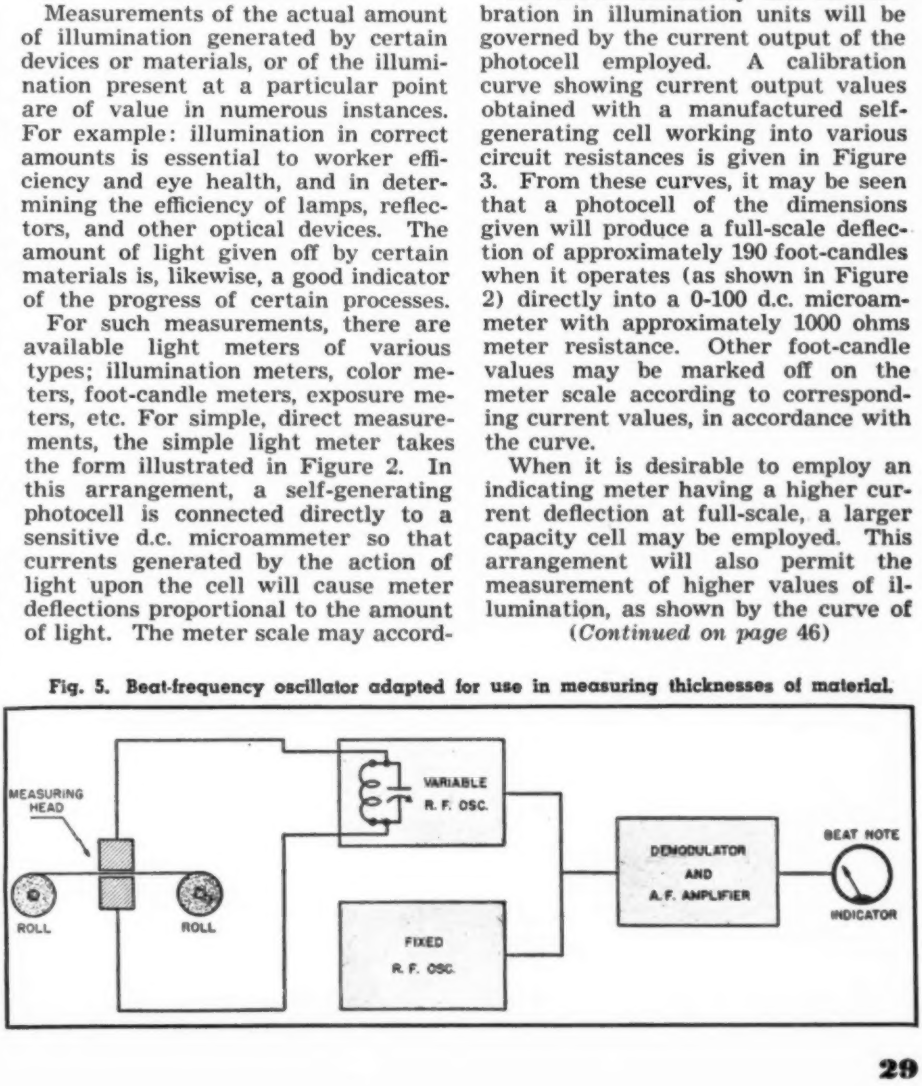
Although a self-generating cell is indicated, and this type of unit will provide the utmost in simplicity and portability, any other type of photocell might be employed if means are provided for supplying the polarizing voltages required by other types.

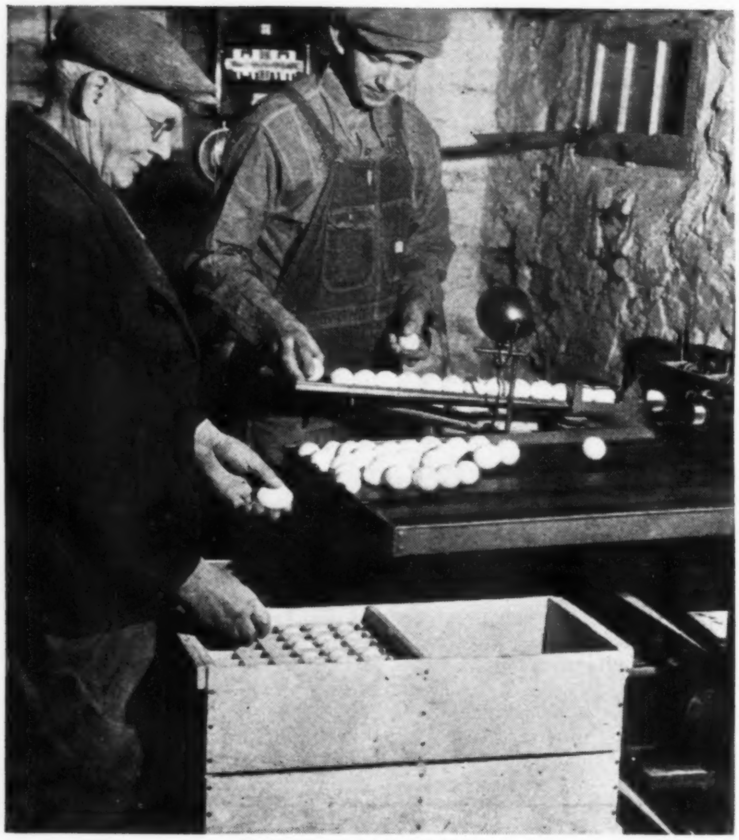
The meter sensitivity and its calibration in illumination units will be governed by the current output of the photocell employed. A calibration curve showing current output values obtained with a manufactured self-generating cell working into various circuit resistances is given in Figure 3. From these curves, it may be seen that a photocell of the dimensions given will produce a full-scale deflection of approximately 190 foot-candles when it operates (as shown in Figure 2) directly into a 0-100 d.c. microammeter with approximately 1000 ohms meter resistance. Other foot-candle values may be marked off on the meter scale according to corresponding current values, in accordance with the curve.

When it is desirable to employ an indicating meter having a higher current deflection at full-scale, a larger capacity cell may be employed. This arrangement will also permit the measurement of higher values of illumination, as shown by the curve of

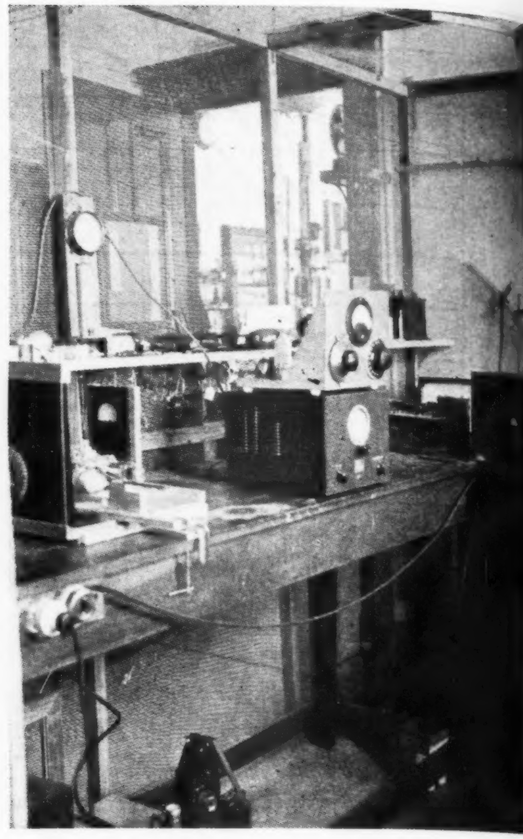
(*Continued on page 46*)

Fig. 5. Beat-frequency oscillator adapted for use in measuring thicknesses of material.





Grading of eggs is an important operation in that industry. Electrically controlled equipment automatically sorts them as to size and quality.



New radionic egg tester in use in the Laboratory of Experimental Embryology, Cornell University.

An electronically controlled trap, with light as bait, reduces the number of tobacco destroying insects in a warehouse.

SCIENTIFIC

by S. R. WINTERS

THE importance of radionics on the farm is proving to be a vital factor in supplying sufficient food to our many war fronts, not to mention the civilians of our Allied nations. There is an extreme shortage of manpower on the farms today, and radionic engineers, coping with these problems, have made available numerous devices as aids to agriculture. Many of these devices are not new, as it was originally intended to devise some means to aid the farmer in eliminating many of his daily monotonous chores. However, with the advancement of scientific knowledge has come new and more elaborate equipment so that ultimate vitamin content and maximum quantity of all agricultural products can be obtained.

Perhaps the greatest contribution that radionics has made to the farmer has been in the many devices which contribute to a saving in manpower.

Photoelectric lighting control for yard and barn lights automatically operates when daylight falls below the desired level.

Automatic operation of poultry houses, whereby lights are turned on at prearranged times to stimulate laying of more eggs, is an accomplished fact. Doors are opened when it is desired to allow the chickens to leave the hen house for food and exercise.

The dairy barn can be equipped with a germicidal lamp for destroying airborne bacteria. Screens charged with

Through the use of electric heaters and electronically controlled lighting systems, an increase in egg production has been obtained.

Electronic microscope makes it possible to study animal diseases. The live 10-day-old embryos are used in place of laboratory animals.

FARMING . . .

The advent of radionic devices has made possible the vital increases in quantity and quality of food production.

electricity, for destroying flies and other insects before they enter the milking quarters, are available.

Sterilization of milk bottles by means of ultra violet light has proven very successful. In the past, hot water solutions and germ destroying chemicals have been used, but when the bottles are rinsed with water from municipal sources, much bacteria remains; although harmless, they cause milk to sour. Intended primarily for dairy farmers, this "sterilamp" may be adapted to bottling operations in the manufacture of soft drinks, canning plants, and in the production of drugs.

From the above it can readily be seen that a great saving in manpower is resulting from the use of these radionic aids to the farmer—a saving that will no doubt continue to grow as more and more of these devices are made available.

Equally as important as the manpower problem is that of increasing production. In this field also, radionics is playing a great part.

Much progress has been made in perfecting the use of X-rays for improving strains of plants and fruit trees. Experiments carried out at General Electric Co., using X-rays at 1,000,000 volts, have been undertaken with apple trees, berry bushes, tomato seeds, and string beans, to determine the genetic effect of electrons on growing things.

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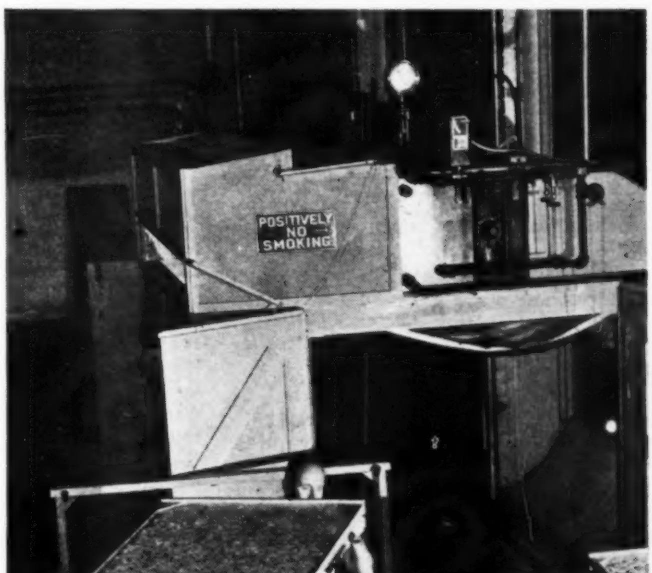


Blanched shredded cabbage, ready to be run through the dryer. Dehydrated fruits and vegetables are more compact for shipment.

DELAY AND TIMING CIRCUITS

By RUFUS P. TURNER

Consulting Engineer, RADIO NEWS

Practical data on electronic systems for time-delay and timing operations, presenting fundamental theory and applications.

ALL present indications are that electronic devices will play a star role in the post-war world. Several well-known agencies have been at work for more than two years acquainting the general public with the wonders of modern electronics. And already, a large amount of non-radio tube equipment has graduated from the mere gadget class to find worth-while application *today*. Both the civilian technician and the military radio specialist will do well to learn everything possible about these things to come, in order to fit more securely into the peacetime technical picture.

This magazine has long followed the avowed purpose of offering circuits and data to clarify the subject of electronics. This service, which has been carried on for the benefit of the enterprising technician, is extended this month to include delay and timing circuits.

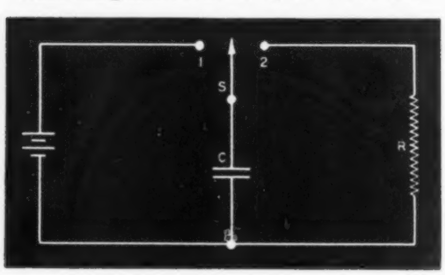


Figure 1.

These circuits make it possible to obtain delayed action of electrical or mechanical devices at predetermined instants, to control instruments or machinery over prescheduled time intervals, repetitious operation at selected rates, interval timing in a number of machines and devices, and many similar operations. While space does not permit the explanation of all the practical systems which are in present use, the rudiments of the most efficient delay and timing systems will be explained and a selected group of circuits described.

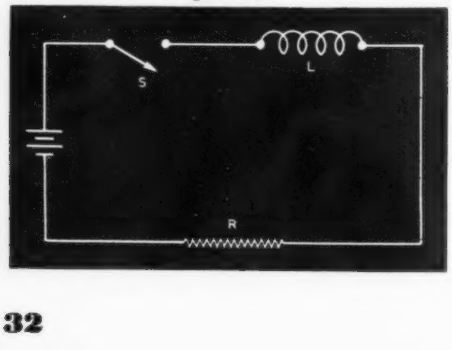


Figure 2.

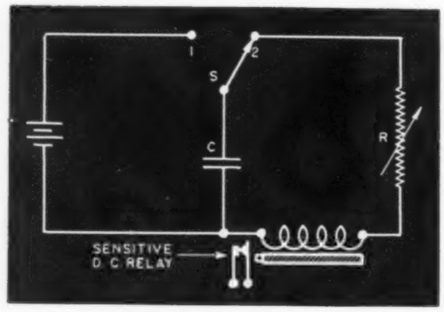


Figure 3.

Development

Prior to the introduction of electronic equipment, delay and timing actions of various sorts were obtained by means of mechanical devices. Most of the latter systems were based upon clockwork or motor-driven mechanisms. And, while some of them were highly successful and are still to be found in use, almost none of these arrangements was simple or inexpensive, and only high initial cost and continued maintenance could guarantee stability of operation.

In electronic delay and timing equipment, on the other hand, absence of moving parts in the actual timing mechanism precludes wear, sticking, and mechanical breakdown. And at the same time, the detrimental effects of inertia are removed, since there are usually no heavy moving parts in electronic systems.

Basic Principle

Most electronic and simple-circuit delay and timing systems are based upon the time constant of simple resistance-capacitance or resistance-inductance networks, or a combination of the two.

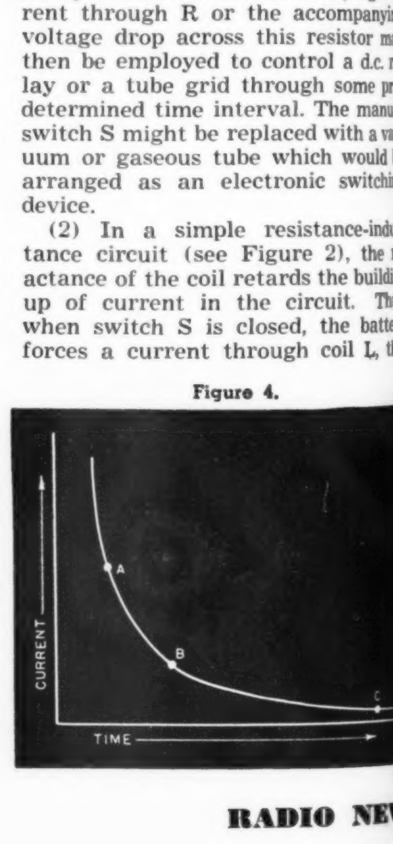
The delay action in each case depends upon the R-C or R-L values and the attendant time required for a current to build up or decay in these simple circuits. The retarding action of these reactances and resistances is utilized to obtain either postponed control actions or to measure actual time intervals.

The underlying principle of each circuit is explained briefly in this manner: (1) In a circuit containing a resistor and a charged capacitor in series, the capacitor discharge current will be limited by the resistor to an extent depending upon its actual value and the amount of current available. The time required for the capacitor to discharge completely will thus be determined by both the R and C values. The *time constant* of this circuit equals R times C (where R is measured in ohms and C in microfarads) and is the actual number of microseconds required for the current to fall to 37 percent of its initial value. The time required for the current to fall to 10 percent of its initial value is equal to 2.4 R-C microseconds.

A basic R-C delay circuit is shown in Figure 1. In this arrangement, when switch S is in position 1, capacitor C is charged by the battery (or other d.c. source). When the switch is subsequently thrown to position 2, the capacitor discharges through resistor R at a rate determined by the R-C product. Either the decaying current through R or the accompanying voltage drop across this resistor may then be employed to control a d.c. relay or a tube grid through some predetermined time interval. The manual switch S might be replaced with a vacuum or gaseous tube which would be arranged as an electronic switching device.

(2) In a simple resistance-inductance circuit (see Figure 2), the reactance of the coil retards the building up of current in the circuit. Thus, when switch S is closed, the battery forces a current through coil L, this

Figure 4.



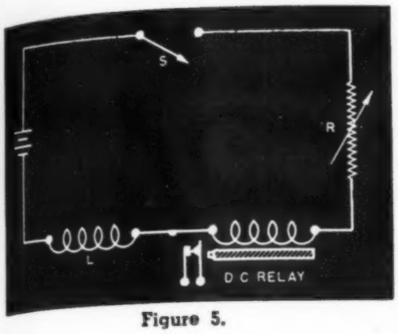


Figure 5.

current increasing in value at a rate determined by the values of R and L. The time constant of the R-L circuit is equal to L/R microseconds, which is the time required for the current to rise to 63 percent of its final value. Either the increasing current in the circuit or the accompanying voltage drop across the coil or resistor might be employed to control a d.c. relay or tube grid during the predetermined time interval. Here, as in case 1, the switch S may be replaced with a vacuum or gaseous tube as an electronic switching medium.

From the foregoing explanation, it is seen that operation may be obtained at practically any instant desired after a circuit is closed or interrupted. The technician needs only to choose the proper circuit constants from the equations to suit his requirements.

Delay Circuits

It is often desirable in the control of electrical devices or machinery to have complete action occur at some stated time after a switch has been closed, or to have action continue for some time after a switch has been opened. For these purposes, delay circuits are employed, and descriptions of several such circuits follow.

SYSTEM 1. This system, most rudimentary of delay devices, is illustrated by Figure 3. The circuit embraces a capacitor C, d.c. source, double-position, single-pole switch S, timing resistor R, and sensitive d.c. relay. With the switch in position 1, the capacitor is charged. In switch position 2, the capacitor discharges through the circuit containing the resistor and relay, the decaying current following the general shape of the curve shown in Figure 4. At first, the current falls rather rapidly and tnen tapers off to a slower rate of decay, until it is completely spent, although by proper choice of R and C values the curve may be made more gradual throughout or steeper at will. Likewise, if a single capacitance value is chosen, the resistor may be made variable, as shown in Figure 3, and a large number of time curves obtained by setting R at various values.

Depending upon the minimum current requirement of the relay, the contacts will be controlled over a portion of the time-current curve, such as between A and B in Figure 4. After reaching a minimum value (as at B), the armature of the relay will be released. If the relay contacts are normally open, the relay will close an external circuit during the delay interval. If, on the other hand, the contacts are normally closed, the relay

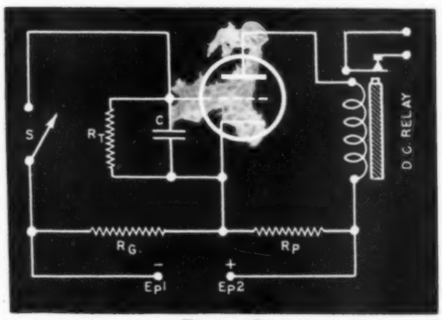


Figure 7.

will open an external circuit during the delay interval.

A highly-sensitive relay is required for operation in this circuit, in order that the armature may be actuated by the very low capacitor discharge current. At the same time, the inductance of the relay coil must be taken into consideration in the selection of R and C values, since this inductance will exert some influence upon timing

SYSTEM 2. Almost the exact reverse of the operation just described may be obtained with the circuit shown in Figure 5. Here, timing is controlled by inductance and resistance components.

When switch S is closed, current flows through the circuit, building up slowly to a maximum value because of the inductance present, in a manner similar to that shown in the curve in Figure 6. The shape of this curve may be altered considerably by the

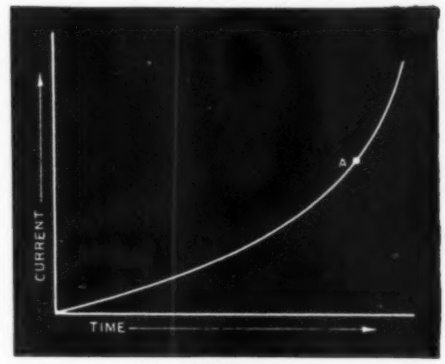


Figure 6.

actual value of the resistance with respect to a given value of inductance; hence by making R variable, as shown in Figure 5, various time intervals may be obtained.

When the current in the circuit rises to the minimum holding value required by the relay, as indicated by point A on the curve in Figure 6, the relay picks up and remains actuated until the circuit is again interrupted by opening the switch. In this system, control action occurs at some instant after the switch has been closed and continues until the switch is subsequently opened.

Very often, it is possible to dispense with coil L entirely and utilize the inductance of the relay coil exclusively as the L element of the timing circuit.

SYSTEM 3. The sensitive d.c. relay required by system 1 is relatively expensive and is frequently susceptible to vibration. More rugged relays require higher operating current than

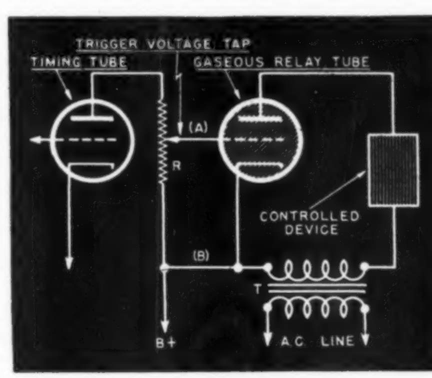
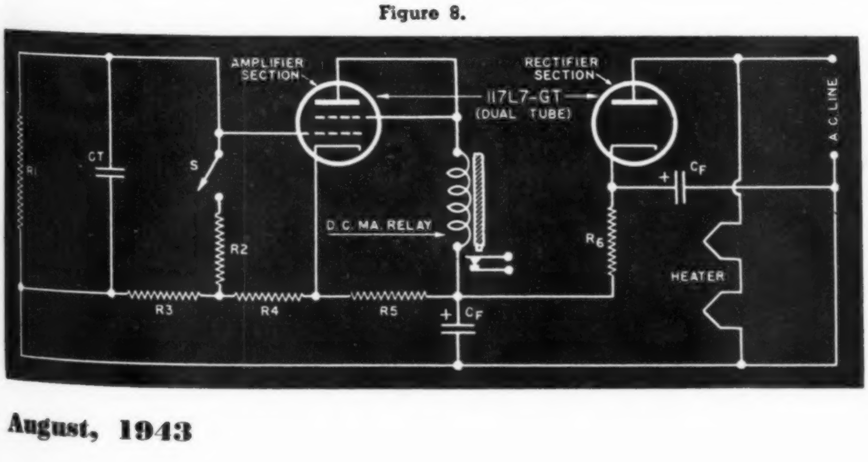


Figure 9.

may be supplied by the capacitor discharge. In order to utilize the low current level and accompanying low voltage drop in circuits of this type, the higher current relay may be interposed in the plate circuit of a tube, the latter's grid being actuated by the low-level delay circuit. Such a system is illustrated in the schematic diagram (Figure 7).

In this system, the type of tube is not important, as long as its normal plate current resulting from voltage impressed at terminals E1 and E2 is sufficient to actuate the d.c. relay. Plate voltage is obtained from the drop across resistor Rp, while grid bias voltage is obtained from the drop across resistor Rg. The latter is pro-

Figure 8.



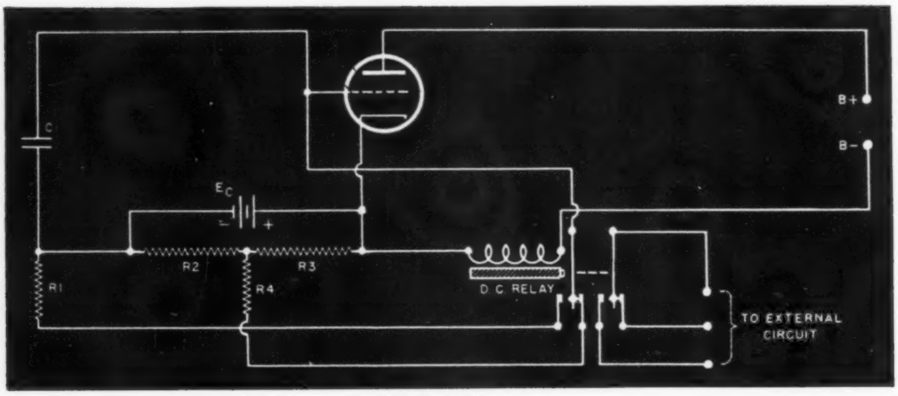


Figure 10.

portioned so as to make the grid highly negative, reducing the plate current below the level necessary to close the relay. When switch S is closed, this high negative bias is applied to the grid and the relay drops out.

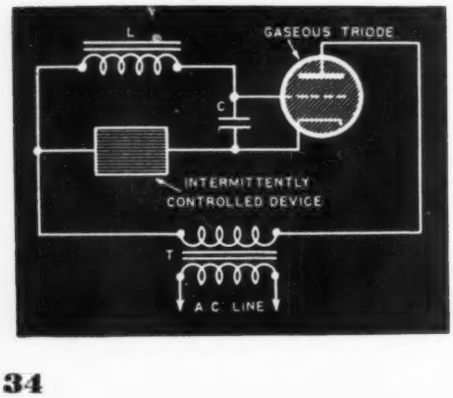
Capacitor C is charged by the grid voltage when the switch is closed. When S is opened, however, the capacitor discharges slowly through its shunting resistor Rt, lowering the voltage of the grid. As the bias continues to fall, the plate current accordingly rises, finally reaching a value at which the relay will be automatically actuated.

The time delay obtained in this circuit is approximately three seconds per microfarad (in C) per megohm (in Rt) for a d.c. voltage (at El and E2) of approximately 100 volts. The values of Rp and Rg will depend upon the type tube employed in the circuit: Rp will be large enough to develop a plate-cathode voltage (as measured with a very high-resistance d.c. voltmeter) such that the grid voltage developed by Rg will reduce the plate current sufficiently to drop out the relay. By making Rt variable, various time delays other than that stated above may be obtained at will.

SYSTEM 4. The circuit of Figure 8 shows a compact tube-type delay circuit requiring only one tube for both power supply and timing functions. A 117L7-GT is employed.

In operation, closing the switch permits capacitor Ct to charge through the resistor R2, 100 to 200 ohms. The grid bias voltage is thus the drop across R4, a value sufficiently low to permit the relay to be picked up. Ct discharges through R1 when the switch is opened, increasing the bias voltage

Figure 11.



until the reduced plate current causes the relay to be dropped out.

R3, R4, and R5 are sections of a 50,000-ohm 75-watt wirewound resistor. The taps are adjusted to obtain a value of plate-cathode voltage (developed across R5) of such value that the bias voltage (developed across R4) is not quite high enough to drop out the relay. R6 is a 2500-ohm 25-watt filter resistor, and the capacitors Cf each 8-μfd. 450-volt electrolytic filter units. This unit is a. c. operated requiring no transformers, or it may be operated directly from a direct-current power source.

SYSTEM 5. In some control operations, it is desired to make and break

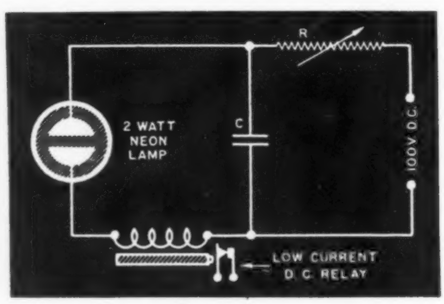


Figure 12.

a load circuit at a definite rate. Such operations include the flashing of advertising lights, signal systems, life tests of machinery and devices, and similar applications. Figure 10 illustrates one circuit for accomplishing this intermittent action by means of delay action.

Here the actuating switch shown in the preceding schematics is replaced by a pair of auxiliary contacts on the relay, so arranged that when the relay is released, the timing capacitor is automatically switched back into the charging circuit. R4 is the timing circuit resistor, and the battery Ec represents the d. c. charging voltage source.

SYSTEM 6. Thyratron tubes may be employed to control an electrical device directly without the intermediary of a relay. The gaseous tube selected need only pass sufficient anode current to operate the device, its grid voltage being obtained from a resistor in the plate circuit of the timing tube. A suggested arrangement is shown in Figure 9.

The timing tube is assumed to be included in a circuit of the type described in the foregoing paragraphs. The customary d. c. relay is replaced in its plate circuit by the load resistor R. A portion of the voltage drop across this resistor is selected by means of a tap and applied as bias voltage to the gaseous tube grid. The value of this voltage and its polarity will depend upon the type of gaseous tube employed as an electronic relay, since various types of Thyratrons require various trigger voltages, some being positive and some negative. Figure 9 indicates a positive trigger voltage applied to the gaseous tube grid. If the actual tube employed by the reader requires a negative triggering voltage, the leads (a) and (b) need only be reversed.

Plate voltage to the gaseous tube is supplied by the transformer T. The controlled machine is connected directly in the Thyratron plate (anode) lead, as shown.

Operation of the circuit follows the scheme of the system adopted for the timing portion of the circuit and may be any of the systems described up to this point. The only difference in the arrangement is the substitution of an electronic relay for the usual electro-mechanical relay. Whether the circuit starts or stops the controlled device depends upon the R-C timing circuit actuating the grid of the timing tube.

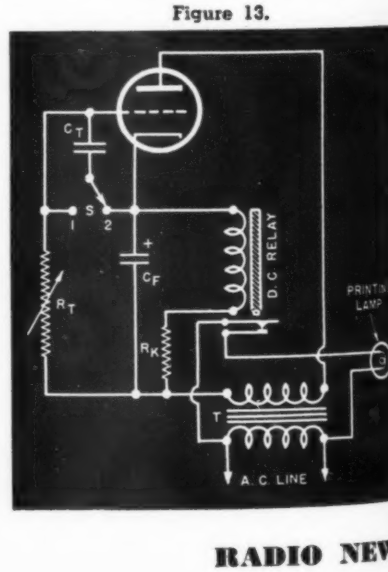
SYSTEM 7. Gaseous triodes may likewise be employed in intermittently-operated systems, such as flashers and interrupters, completely eliminating the relay specified in Figure 10. Such a circuit is shown in Figure 11. Here, the Thyratron chosen passes sufficient anode current to operate the intermittently-controlled device directly, and is powered directly by the transformer T.

Action of this circuit is based upon the retarding effect of the inductor L upon charging current flowing into capacitor C. The rate at which the intermittent control occurs may be set by choice of L and C values.

When current is passing through the controlled device, the capacitor charges at a rate determined by the

(*Continued on page* 78)

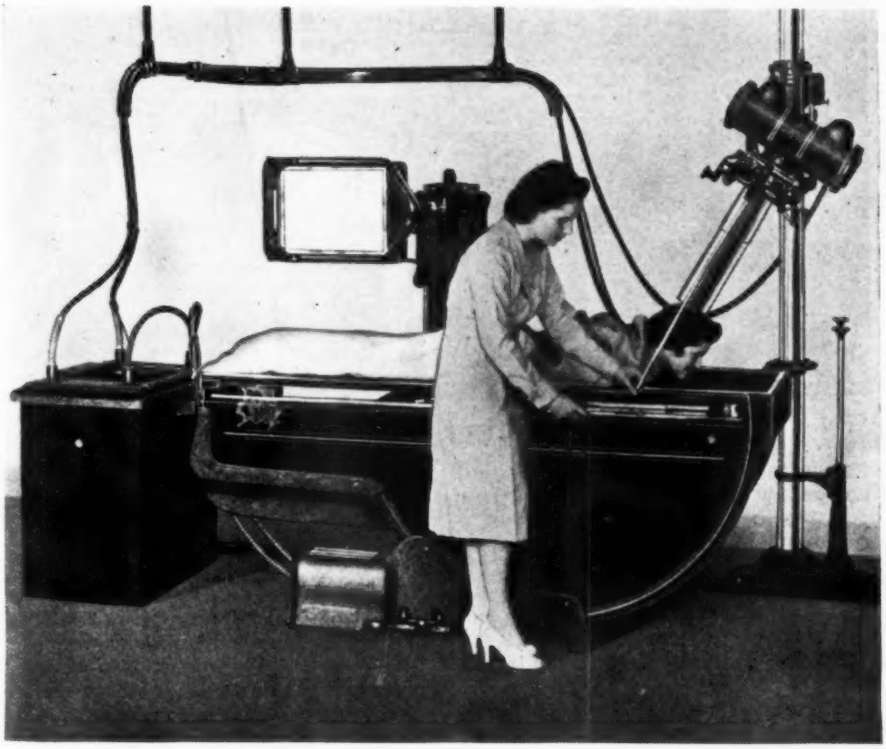
Figure 13.



ELECTRO-MEDICAL APPARATUS

by JOHN KANE

A study of service problems encountered in electronic-controlled units.



Modern type of combination X-ray and fluoroscope equipment. Extreme flexibility of the table and equipment makes it possible to examine thoroughly any part of the body.

THE radio serviceman sometimes finds it necessary or desirable to be able to make minor repairs on X-ray or other electro-medical equipment. This may be due to an emergency or when the regular maintenance service of the manufacturer is too slow or the manufacturer has gone out of business. This article is intended to acquaint the technician with the basic principles of equipment used in the medical field.

X-rays were discovered by Roentgen in 1895. Here was one of the foremost developments in the electronic art before the catchword of "electronics" had been coined. The X-ray tube is much like a high voltage radio tube. It has two elements, a cathode and a plate of special shape. Roentgen found that when high velocity electrons from the cathode struck the tungsten plate X-rays were generated. In some tubes a platinum plate is used. The hard X-rays extend

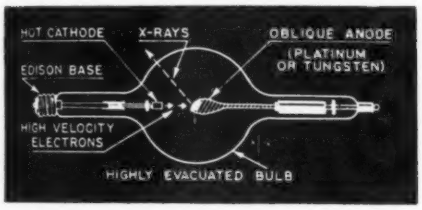


Fig. 1. Coolidge X-ray tube.

up to 10^{20} cycles per second, the soft to 10^{19} c.p.s., while the highest radio frequency signal produced electrically is about 10^{13} cycles per second. The frequency of visible light is about 10^{15} cycles per second. The frequency of ultra-violet light is from 10^{15} to 10^{17} c.p.s., infra-red from 10^{13} to 10^{14}, approximately.

In connection with X-ray apparatus we find that there are three rather imposing names given to the applications of the equipment. The first is Roentgen Therapy. The word therapy signifies a treatment for disease. Thus, we may have occupational therapy for mental cases and in X-ray work we have Roentgen Therapy for physical ailments. But this is a matter for the X-ray technologist and medical terms need have no great concern, as far as the electrical expert is concerned, beyond understanding the requirements of the device. His job is to repair apparatus.

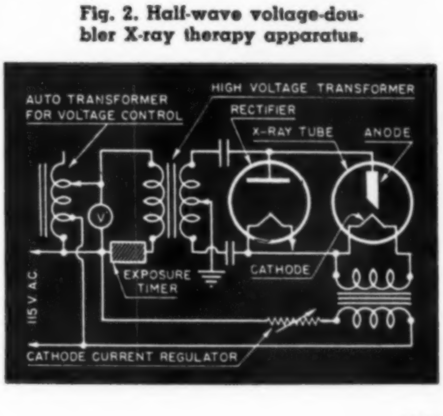
The kind of X-ray equipment used for therapeutic use, exposure of body parts to radiation, depends upon the region that is to be treated. Remembering that 1 meter equals 10^{10} Angstrom units, we may convert frequency in cycles to wavelength in meters and then convert to Angstrom units (A). For skin treatment it has been found that Grenz rays are useful, having a radiation wavelength of 2 to several hundred A units. The X-ray tube voltages range from 135,000 to 300,000 peak. A filter is placed between the source of rays and the patient. It consists of a few millimeters of aluminum, a few tenths of a millimeter of copper or some combination arrangement. The filter absorbs a great deal of the low frequency radiation that otherwise would be absorbed by the skin. The rays that get through the filter are applied to the area to be treated. In treating cancer, gamma rays have been used successfully but so far the use of X-ray tubes for producing gamma radiation has not been proven an absolute success. Experiments have been carried on with tubes worked at 300,000 to 1,200,000 volts.

Radio amateurs and commercial operators, as well as others having familiarity with high power, will find the circuit of Fig. 2 recognizable. Usually a half-wave rectifier is employed using a tube for changing the a.c. wave into d.c. and in many cases voltage doubling is used. The half-wave voltage doubling arrangement shown in Fig. 2 is typical and widely used in the medical profession.

The weight of a typical, complete installation may range from 990 to 1760 pounds which is not unusual considering massive equipment necessary.

As is well known, X-rays are detected by photography. It was in fact accidental that Roentgen discovered the rays, observing the peculiar effect on a photographic plate connected with some other experiment on which he had been working. X-rays also have the power to excite fluorescence. They are not affected by a magnetic field. They are reflected to some extent and slightly refracted by prisms and lenses, indicating the optical qualities of the radiations, but also have the well known and remarkable power

Fig. 2. Half-wave voltage-doubler X-ray therapy apparatus.



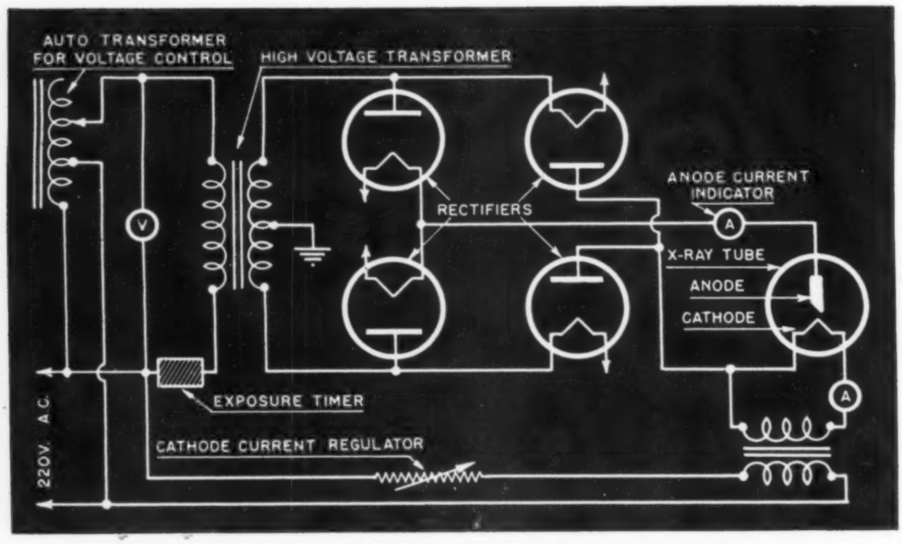


Fig. 3. Schematic diagram of full-wave single-phase Roentgenographic machine.

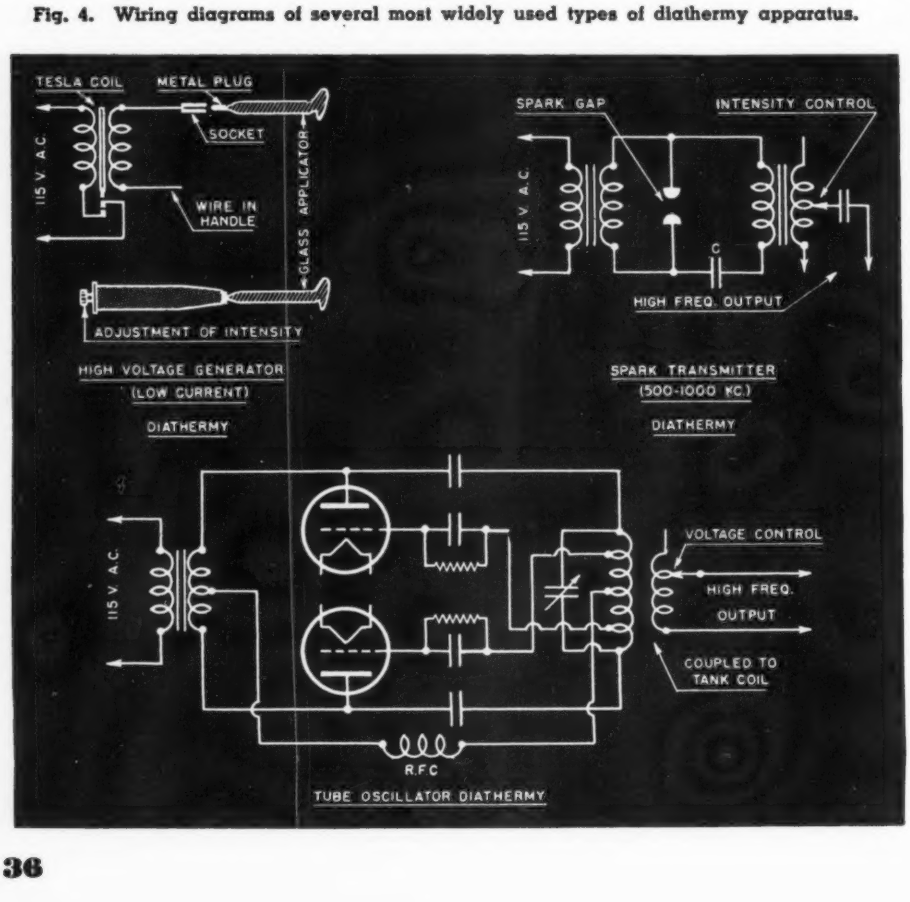
of penetration of substances of small density, such as wood, pasteboard or body tissue which are all opaque to ordinary light. They penetrate metals to a lesser extent, considerable attenuation being observed in the more dense metals such as platinum and lead. Nevertheless industrial uses for X-rays in analysis of steel and iron have been found.

Fine crystals of barium platinum cyanide or calcium tungstate may be deposited upon a piece of pasteboard and if brought in a dark room before an X-ray beam, the pasteboard will glow. Body tissue, being transparent to the rays, will show but faintly while the bones will cast a strong shadow. By substituting a photographic plate for the fluorescent screen we can obtain an X-ray photo, showing broken bones, etc., of any part of the body.

The Coolidge X-ray

This tube (Fig. 1) is a highly evacuated type with a hot cathode, the voltage which may be applied being limited only by the spark-over characteristic of the tube, large tubes being operated on voltages as great as 200,000 and even higher. The high potential tubes have electrons in them traveling at extreme velocities and produce X-rays of great penetrating force. This necessitates careful screening of the apparatus with sheet lead, or an equivalent material, which absorbs radiation and prevents X-ray burns which are serious and dangerous to the operator of the equipment.

Fig. 4. Wiring diagrams of several most widely used types of diathermy apparatus.



Classes of X-ray Apparatus

The three forms of roentgenographic machines may be arranged categorically in the following way: single-phase, three-phase and condenser discharge. The first part of the word roentgenographic is of course taken from the inventor's name, Roentgen, while the second part indicates a written record. The apparatus which records is thus a roentgenographic and that which permits a visual inspection is roentgenoscopic. The science of X-ray seeing is roentgenoscopy (fluorescent action).

A complete dental apparatus of the self-rectification type may weigh about 265 pounds. It may occupy a space of about 24 x 24 x 80 inches. The film used is generally contained in a light tight cassette (box used by photographers as a plate holder) having a front plate of thin bakelite or thin aluminum. Two intensifying screens are used in the cassette, one on either side of the film and maintain close contact with it when the cassette is loaded. The X-rays pass through the screens and produce a fluorescent effect in the calcium tungstate or zinc sulfide contained and the resultant light radiation acts upon the film. About 5% of the density is caused by the absorption of X-rays in the film and the screens produce the other 95% in modern equipment. To control contrast in the roentgenograms, the X-ray tube voltage is varied. For roentgenography of the chest and heart, exposures of $\frac{1}{120}$ to $\frac{1}{5}$ second are used, while other parts of the body may be X-rayed at exposure times of $\frac{1}{2}$ to 20 seconds. The X-ray tube current is measured by a standard milliammeter for exposures longer than 3 seconds. The X-ray tube voltage is generally measured by means of a sphere gap and calibrated for the given value of used current, being checked against the primary voltmeter reading.

For exposures of very short duration, a ballistic milliampere-second meter is used to measure the total value of current passed through the X-ray tube and the timer is arranged to make and break the contact controlling primary current at zero points of the first and last cycle of exposure. The distance between the target of the tube and the film generally ranges from about 18 to 80 inches. The anode current indicator shown in the plate circuit (Fig. 3) of the X-ray tube is a ballistic milliampere-second instrument. The X-ray tube current for general roentgenoscopy may range from 5 to 10 ma., while in roentgenography the current may range from 50 to 1000 milliamperes average.

One of the most spectacular and at the same time one of the most useful applications of radio technique is in connection with electrosurgery. One large electrode is applied to the body and the other electrode is a large

(*Continued on page* 58)

Manufacturers' Literature

Our readers are asked to write directly to the manufacturer for this literature. By mentioning RADIO NEWS and the issue and page, we are sure the reader will get fine service. Enclose the proper sum requested when it is indicated. This will prevent delay.

STANCOR'S NEW TRANSFORMER CATALOG

The Transformer Encyclopedia of the Radio and Electronic Industry contains detailed specifications covering *Stancor's* complete line of transformers and chokes for replacement and general purpose use. A handy classified and numerical index and price list permit instant location and cost estimate of the item you want. Many pages are devoted to transformers designed for special shop, laboratory, and industrial applications. Catalog is illustrated throughout with mounting types available. Send your request for a copy of Catalog No. 140 to the *Standard Transformer Corp.*, 1500 N. Halsted, Chicago, Ill.

WAR TIME TUBE SUBSTITUTION CHART

The Sales Engineering Department of *National Union Radio Corporation* at Newark, New Jersey released this week for distribution through National Union distributors a War Time Tube Substitution Chart which includes a functional cross index.

The compilation indicates substitutions of approved Government types for 288 types available prior to the Government limitation order.

Preferred substitutions are shown in each instance and types are coded to indicate necessity of changes such as changing sockets, changing bias, using external shield, using filament shunt, rewiring sockets, etc.

In addition to the interchangeability listing a functional cross index shows the replacement with regard to functional considerations vs. heater considerations.

A copy of the chart may be obtained by recognized servicemen and technicians on request to *National Union* distributors in local areas.

MANUAL OF SIMPLIFIED RADIO SERVICING

By Lieut. Col. J. G. Tustison, U. S. Army Signal Corps. Published by *Allied Radio Corporation,* 833 West Jackson Boulevard, Chicago, Illinois. Forty pages, pocket-size, 5" by 3¼". Price, 10c.

This booklet describes practical field-tested short-cut methods for servicing Electronic and Radio devices with only the simplest equipment and tools. Many methods described are those used by our armed forces for servicing

(*Continued on page* 66)

WAR—BY RADIO

by S. L. SOLON

ON THE morning of May 30, 1916, an observer in the Royal Navy bent over his wireless direction-finding equipment. He twirled the knobs of the somewhat clumsy apparatus, listening carefully to the staccato crackling of the ether.

Had the time come? He must be certain before he reported.

Again he checked his results. More than a new technique of direction-finding was in the balance. The Grand Fleet strained at anchor waiting to engage the Kaiser's armada.

The observer lifted his phone. "Beg to report, sir, there is unusual signalling activity among the German ships at Wilhelmshaven." All that morning the reports poured into the office of the First Sea Lord, Sir Henry Jackson. In the afternoon wireless direction-finding observers reported that a German battleship had moved a few miles northward.

This was the final link in the chain of evidence built up during the day by wireless direction-finding. The German Fleet was about to put to sea.

Sir Henry ordered the Grand Fleet to sail at once. It sailed into history by the victory over the German Fleet in the Battle of Jutland. And it was the first elementary steps in wireless location that made this smashing blow to German sea power on the high seas possible.

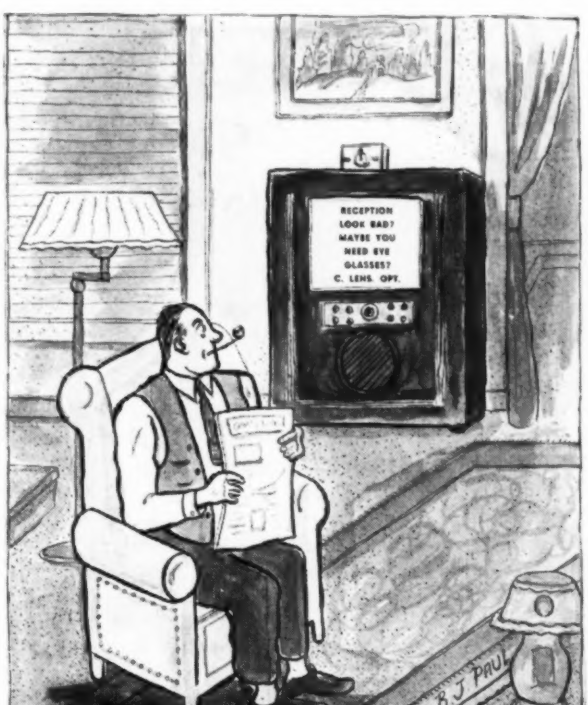
The fuse of the great Battle of Jutland was lit by a tense young man, listening to the electrical pulse-beat of the German Fleet crackling through the ether. The instrument he depended on—the tangled web of wire coils, luminescent valves, sputtering electrodes like the living organs of some mechanical Scylla — was the grandfather of modern radiolocation. It is radiolocation, sturdy shield to the R.A.F. lance, that shares the glory of the Battle of Britain.

Greatest achievement in wireless warfare in the Second World War, radiolocation is but one of many developments in war by radio which have kept the experimental laboratories on a 24-hour daily working schedule since the Nazi Panzer colossus rumbled over Poland in the fall of 1939.

The full story of the Battle of Science cannot be told until the war is won. The endless quest for new techniques, new weapons, new means for attack and defense is, like the story of any battlefield, a record where success alternates with failure, heroism with disaster, heartbreak with achievement.

Men die in agony, are maimed and shattered in the secret Battle of Science as inevitably as the soldiers on other battle-fronts of the world.

In every phase of warfare—mechanization, aircraft, ordnance, communications, munitions and morale — science presses forward. Perhaps the most sensational developments, however, have taken place in wireless warfare—the use of the invisible air waves as a vehicle for attack and defense.



It is in radio warfare that the most startling and interesting possibilities lie. I have talked to men who are working in this field—the explorers of invisible worlds and the experimenters in invisible matter—and as far as it was possible I have watched what they are doing. Here are the notes of this brief glimpse into the Battle of Science and some of the accomplishments of the men who are fighting it.

Writing of "War in 2030," the Earl of Birkenhead a few years ago

(*Continued on page* 64)

PRACTICAL RADIO COURSE

by ALFRED A. GHIRARDI

Part 16 of the series, covering the present day design characteristics and circuit application of power amplifier tubes.

THE operation of all practical forms of loudspeakers in common use in radio receivers and sound amplifier systems (see Fig. 1) depends upon the fact that a varying current flowing through their actuating windings produces motion of some sort of diaphragm which results in the production of sound waves. This varying signal current flowing through the loudspeaker winding constitutes a supply of *electric power* that is being delivered to it for its operation.

It is important to remember that the amplitude of the *variations* in the current, not the *total* amplitude of the current itself, determines how great the amplitude of the diaphragm vibrations produced will be and, consequently, how intense the resulting sound waves will be. In other words, the greater the amplitude of the variations in the signal current, the louder the reproduced sound will be. (These variations or fluctuations are the useful portion of the total plate current of the tube or tubes feeding the loudspeaker, and are referred to as the *a.c. component of the plate current.*)

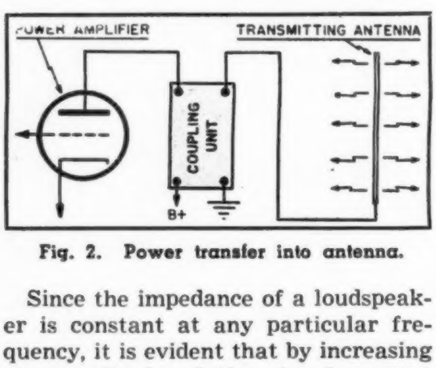


Fig. 2. Power transfer into antenna.

Since the impedance of a loudspeaker is constant at any particular frequency, it is evident that by increasing the amplitude of the signal current flowing through its actuating winding a larger amount of electric power will be delivered to the loudspeaker and the sound will be louder.

Since it is the *electric power* of the amplified signal fed to it that actuates the loudspeaker, the function of the tube or tubes immediately preceding the loudspeaker is to deliver the maximum possible amount of *undistorted signal power* to the loudspeaker. For this reason they are called the *power amplifier tubes,* or simply the *power tubes* of the amplifier (Fig. 1).

The case of the tubes employed in the radio-frequency amplifier of a radio transmitter is similar. In order to radiate signal energy from the transmitting antenna electrical signal power must be delivered to the antenna circuit (Fig. 2). Consequently, it is the signal *power* output obtained

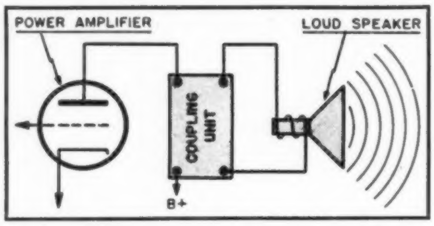


Fig. 1. Tube used to operate speaker.

from the radio-frequency amplifier tubes feeding the antenna circuit that is important here, and these tubes are called the radio-frequency *power amplifiers.*

When vacuum tubes are employed as amplifiers in an electronic circuit where a relay, solenoid, electromagnet, lamp, etc.(see Fig. 3), is to be operated directly from the plate circuit of an amplifier tube, the tube is being called upon to deliver electrical *power* to the device it is to actuate. In such applications it is usually desired to obtain the maximum *power* output from the tube, consistent with conservative operation of the tube within its ratings. Signal distortion here is usually of no consequence.

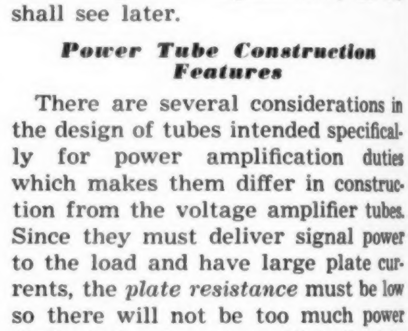
Difference Between Voltage and Power Amplifier Tubes

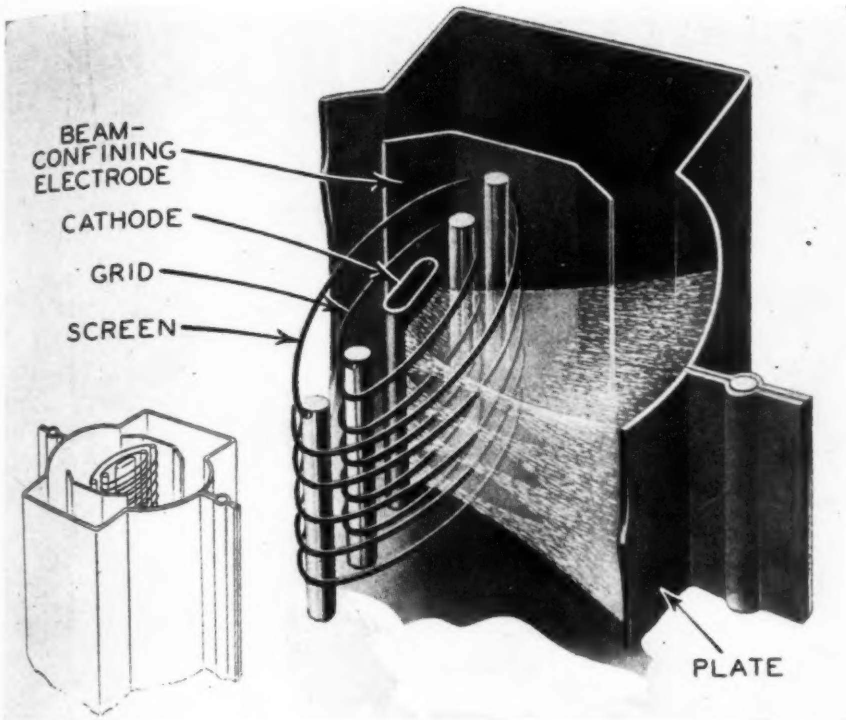
The question that now arises is what determines whether a tube is a *voltage* amplifier or a *power* amplifier. First of all, it is the circuit constants of its coupling network and, to some extent, the voltages applied to its various elements. Thus, a tube is called a *voltage* amplifier when the circuit constants of its associated coupling network are so adjusted that the tube will deliver as much signal *voltage* as possible to the following device (which is usually the grid circuit of another tube). On the other hand, if the circuit constants of the coupling network are so arranged that the tube will deliver as much *power* as possible to the succeeding device (such as a loudspeaker, etc.) it is called a *power* amplifier. (An exception arises when a voltage amplifier tube is used as a *driver,* in which application it must also deliver *power.*) It is evident from this that *any* amplifier tube may be used either as a voltage amplifier or as a power amplifier by making the proper circuit constant adjustments. However, certain tubes such as the types 50, 2A3, 6K6, 6L6, etc., are designed to operate more advantageously as power amplifiers than as voltage amplifiers when used in suitable circuits, so they are called *power amplifier tubes.* Similarly, when properly used, other tubes such as the types 56, 6F5, 6J7, etc. perform more advantageously as voltage amplifiers than as power amplifiers, hence they are known as *voltage amplifier tubes.* Nevertheless, regardless of this distinction, the same fundamental theory of vacuum tube amplifier action applies equally well for all tubes whether they are voltage amplifiers or power amplifiers. Also, power amplifier tubes produce some voltage amplification as well as power amplification, as we shall see later.

Power Tube Construction Features

There are several considerations in the design of tubes intended specifically for power amplification duties which makes them differ in construction from the voltage amplifier tubes. Since they must deliver signal power to the load and have large plate currents, the *plate resistance* must be low so there will not be too much power dissipated and wasted within the tube itself. Remember that, in general, power dissipation is a function of I^2 and of R. All power dissipated in the internal plate resistance of the tube ($I_p^2 \times R_p$) produces only heat within the tube, and is therefore a total waste of a portion of the power supplied to the plate circuit by the plate supply source. Furthermore, this wasted power produces heat which raises the temperature of the internal parts of

Fig. 3. Plate current relay operation.





Element arrangement of beam power-output tube. Concentrated electron stream, free from secondary emission, makes possible the high power sensitivity of such tubes.

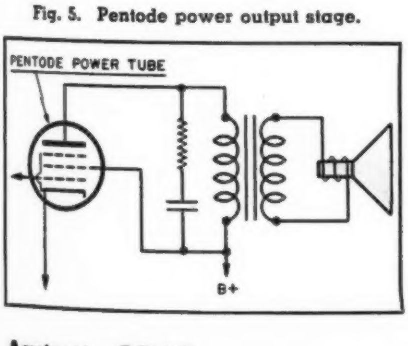
the tube and so limits the useful power handling capabilities of the tube.

Since the signal voltage has been amplified by preceding voltage amplifier tubes before it reaches the grid circuit of the power tube, this tube must be capable of handling, without distortion, quite large variations of signal voltage. This means that its $E_g - I_p$ characteristics curve must be straight over a comparatively large range of grid potential. This is accomplished by using a widely spaced grid.

Since a widely spaced grid must be used, the amplification factor of the tube becomes comparatively low because such a grid has a comparatively small amount of control over the electron stream moving from cathode to plate. Thus, most power tubes have a fairly low amplification factor (for example the mu of a 6A3 power amplifier triode is 4.2, that of a 6A4 power amplifier pentode is 150, etc.).

The amount of power that a tube can handle is determined by the plate voltage that may safely be applied to the tube, by the electron emission of the cathode and by the amount of heat that can be dissipated within the tube without overheating its parts. The large plate current required in power tubes (so that they may deliver large power to the load) necessitates the use of cathodes having a large surface area so that they may emit the copious stream of electrons necessary.

Fig. 5. Pentode power output stage.



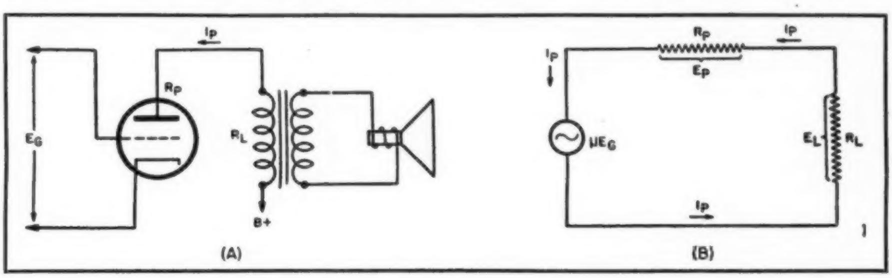


Fig. 4. Triode output tube used to actuate a speaker, and its equivalent circuit.

In some power tubes such as the 6A3, two cathodes in parallel are used.

In order to withstand the high plate voltages employed with some power tubes, it is necessary to provide ample insulation between the plate and other electrodes. In glass envelope type power tubes, the plate, grid, and cathode leads are commonly brought out through separate parts of the glass envelope in order to provide the maximum possible insulation.

The total power dissipated within the tube itself consists of the internal plate and grid circuit power losses plus the power used for heating the cathode. All of this heat must be carried away from the elements, principally through the envelope of the tube. A major proportion of the energy which is to be dissipated is produced at the plate of the tube. Consequently, the plate has to be large enough so it is capable of radiating all the heat generated at its surface, and also the heat radiated to it by the cathode and other elements, without damage or adverse results such as secondary emission, etc. The size of the plate and the glass envelope of air-cooled tubes is proportional to the power capacity.

In tetrode or pentode type beam power tubes, because of the effective suppressor action provided by the space charge, and because of the low current drawn by the screen (see Part 10, Feb. 1943 issue), the advantages of high power output, high power sensitivity, and high efficiency are obtained.

Power Amplifier Circuit Consideration

In radio receiver applications, for a given signal input the power tube is required to release the maximum amount of undistorted signal *power* in its plate circuit which, of course, is subsequently transferred to the load. Even though a particular tube may be especially designed to operate as a power amplifier, it will only perform satisfactorily in that capacity when used in properly designed circuits, having the proper circuit constants, and when the correct potentials are applied to the various tube elements. The power tube, together with its associated circuit components, constitutes one complete *power stage.*

The power output of any given vacuum tube is dependent on the direct operating voltages applied to the various electrodes, on the external load impedance connected in the plate circuit, and on the magnitude of the exciting (signal) voltage applied to the control grid. In any case, the operating conditions are subject to the maximum safe limiting values placed by the manufacturer on electrode voltages, electrode power dissipation, and space current drawn from the cathode (these values may be obtained from the tube characteristics charts published by the manufacturer). The power output obtainable under actual operating conditions in audio amplifiers also depends upon how much distortion from second and higher-order

(*Continued on page* 60)

TECHNICAL BOOK & BULLETIN REVIEW

"BASIC ELECTRICITY FOR COMMUNICATIONS," by W. H. Timbie. Published by *John Wiley & Sons, Inc.*, 440 Fourth Ave., New York City. 590 pp. plus index. Price $3.50.

This book presents basic electrical principles used in the communications and industrial electronic fields. The plan followed is that which has proved successful in the author's Elements of Electricity. Facts and theories are presented by simple direct statements. The book contains an adequate amount of information concerning electrical laws and communication practice in an immediately usable form. Furthermore, it applies the information contained to real situations and modern equipment and not to abstract theory and the jungle of mathematical formulas. It confines itself to adequate treatment of a few fundamental ideas, rather than to a discursive treatment of many. It includes only the elementary electrical principles and their application to modern communication practice and to the rapidly growing field of industrial electronics.

"FIRST PRINCIPLES OF RADIO COMMUNICATIONS," by Alfred P. Morgan. Published by *D. Appleton-Century Company*, New York-London. 353 pp. Price $3.00.

This complete, simple practical course for either individual or group instruction will give the novice a thorough knowledge of radio communications. It starts with basic electrical principles and unfolds each and every subject in simple and logical style. The beginner is given a complete basic understanding of the principles that make each part of a radio transmitter and receiver work, and gradually develops the subject of radio practice. Mathematics has been almost entirely avoided. A few important electrical calculations are explained but they require only ordinary arithmetic or simple algebra for their solution. The book contains approximately 183 diagrams, making all subjects clear to the student. It is a most valuable publication for use in pre-induction courses in radio fundamentals for those who are entering the armed forces and want to specialize in radio communications.

"ALLIED'S RADIO DATA HANDBOOK," by Nelson M. Cooke, Lt. U.S. Navy. Published by *Allied Radio Corporation*, Chicago. 47 pp. Price 25c.

This book fills the need for a comprehensive and condensed handbook of formulas and data most commonly used in the field of radio and radionics. It serves as a convenient source of information and reference. The handbook consists entirely of formulas, tables, charts and data. These are

(*Continued on page* 88)

Radio operator-gunner Wm. Garrett, stands by for action in Flying Fortress.

RADIOMEN IN COMBAT

RADIOMEN have to have what it takes, as their duties include everything from repairing the equipment and brass pounding to transmitter operation. As an added chore they man the guns to beat off enemy attacks. Whether high in the air in a Flying Fortress or in a bouncing, jolting tank on the roughest terrain in the toughest outfits, radiomen are doing their jobs according to the highest traditions of the service, and making radio one of the major contributions to early victory and future world peace.

Radio-equipped Marine tanks in action over rough terrain.

How Color Comparators Work

by JOHN KEATING

A review of the fundamental electronic equipment used for the comparison of colors in industry.

IN several industries, photocells now examine, sort, or match colors with greater precision and less chance of disagreement than has hitherto been possible with trained specialists. Radionic *color comparators* evaluate colors in quantitative terms, exhibit excellent retrace characteristics, and experience no fatigue. Organizations employing these instruments now include textile mills; fitters of automobile upholstery; chemical plants and laboratories; paint, dye, and ink factories; various industries which make use of color as an indication of the progress of certain processes; and many others.

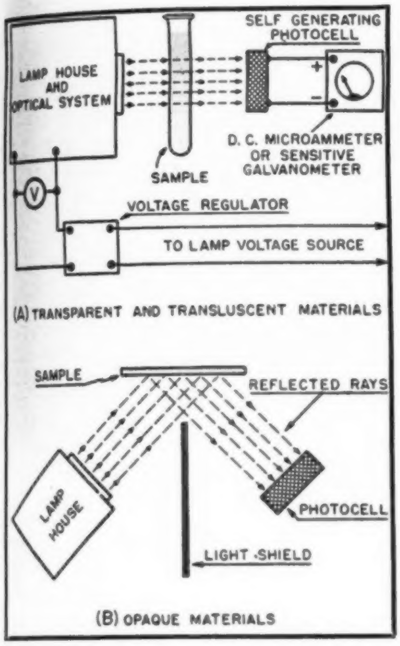


Fig. 1. Fundamental type of color meter.

To appreciate fully the degree of exactness afforded by the color comparator, we must first examine briefly the nature of color. Color, as a quality of visible phenomena, possesses three attributes: *brilliance,* which enables the observer to distinguish light, medium, or dark shades of the same color; *hue,* which differentiates one color from another and is what is ordinarily meant when the term color is used; and *saturation,* which expresses the vividness of a particular hue. When the eye receives a color stimulus, it evaluates each of these attributes to some extent. To be identical, two colors must match in brilliance, hue, and saturation.

The visible spectrum extends from 7800 angstrom units (red) to 3800 angstrom units (violet). The angstrom unit, standard for expressing the wavelength of light, is equal to 0.0000000001 meter, or one hundred-millionth of a centimeter. This represents a considerable frequency band, even when we concede that the visible spectrum is relatively narrow. Most colors are of complex waveform.

The color comparator, in order to be an effective instrument, must evaluate all colors presented to it in terms of hue, saturation, and brilliance. When the instrument is employed for matching purposes, failure to take one of these attributes into cognizance will entail faulty indications. A skilled inspector may experience little difficulty in matching similar colors by eye when viewed together. However, when examined separately, even under identical lighting conditions, sharp differences of judgment arise between different inspectors. This is chiefly because the eye cannot differentiate sharply between small differences in hue, saturation, and brilliance contained in psychological color stimulus.

The most rudimentary type of color meter is illustrated in Figure 1. In this arrangement, monochromatic light delivered by an appropriate optical system penetrates a transparent or translucent color material (or is reflected from an opaque colored material) and impinges upon a self-generating photocell. The latter, in turn, actuates a sensitive d.c. micrometer. An identical circuit has previously been shown as a turbidity meter for use in chemical analyses.

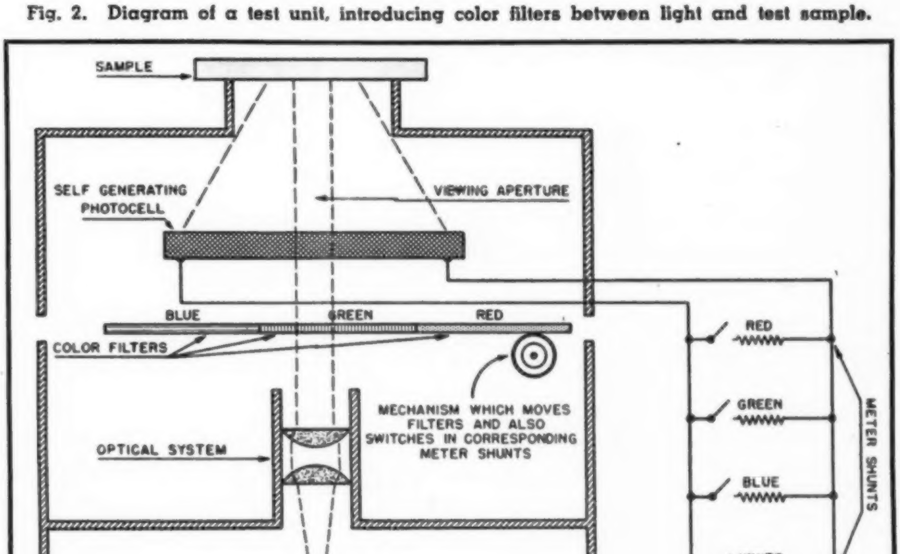
Obviously, the limitations of this simple instrument are severe, chiefly because of its lack of selectivity. If transparent materials, such as solutions in test tubes, are examined, they must necessarily be of constant turbidity, otherwise identical microammeter deflections are apt to be obtained for different colors.

Introduction of primary-color filters between the light source and the test sample will introduce a degree of selectivity. In a color comparator, due to Barss, Knobel, and Young and manufactured some time ago by *General Radio Company* (see Figure 2), these further refinements have been introduced without unduly complicating the instrument.

In this unit, the colored material receives light directed from a monochromatic, constant-intensity source through primary color filters and reflects this light to a self-generating photoelectric surface which is connected directly to a sensitive d.c. meter. Three light frequency bands, corresponding to the red, blue, and green

(*Continued on page* 50)

Fig. 2. Diagram of a test unit, introducing color filters between light and test sample.



WHAT'S NEW IN RADIO

New products for military and civilian use.

NEW FEED-THRU TERMINAL BLOCK

A new multiple terminal block, for sub-panel and chassis construction, with feed-thru terminals, has just been announced. This new terminal block is designed to meet present-day demands of electronic and electrical

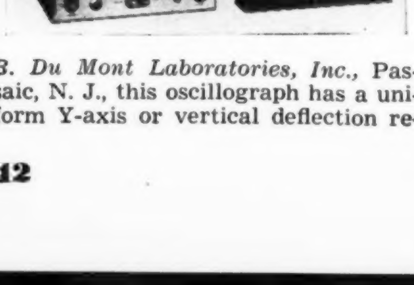
design, which require external terminals, because of their wiring simplicity and other advantages.

Terminals have ample clearances and leakage distances for circuits carrying up to 300 volts, 20 amperes. Center to center distance between terminal units is ⅝". No. 8 screws are used on each side of terminal units for securing connection. The two mounting holes at each end of the terminal base take No. 8 machine screws. These new blocks, known as *Curtis* Feed-Thru Terminal Blocks are offered by *Curtis Development and Manufacturing Co.,* 1 N. Crawford Avenue, Chicago, Illinois. Descriptive literature is available upon request.

NEW 5-INCH OSCILLOGRAPH

Larger screen size together with the inclusion of a Z-axis amplifier to modulate the beam with any signal applied to its input terminals, or with a return trace blanking impulse produced by the linear-time-base generator, distinguishes this new Type 241 *Du Mont* 5-inch cathode-ray oscillograph from the previously announced 3-inch Type 224.

A development and product of *Allen*



B. Du Mont Laboratories, Inc., Passaic, N. J., this oscillograph has a uniform Y-axis or vertical deflection response from 20 c.p.s. to 2 megacycles. It offers a comparably faithful square and sinusoidal wave response. The X-axis or horizontal deflection amplifier has a uniform characteristic from 10 c.p.s. to 100 kilocycles. Both amplifiers have distortionless input attenuators and gain controls. Provision is made to connect signals directly with the deflection plates when frequencies to be observed are beyond the useful limits of the amplifiers. Manufactured by the *Allen B. Du Mont Laboratories, Passaic, N. J.*

NEW SELENIUM RECTIFIER

An important addition to the *I. T. & T.* Selenium Rectifier line was recently announced by Henry H. Scudder, Manager of the Selenium Rectifier Division of *Federal Telephone and Radio Corporation,* manufacturing subsidiary in the United States of International Telephone and Telegraph Corporation.

The outstanding feature of this new

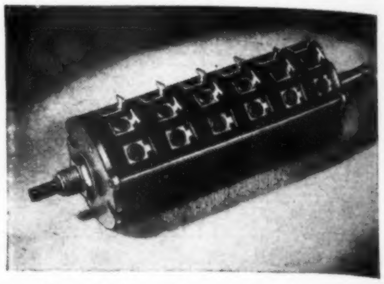
rectifier is the protection provided against excessive humidity and moisture conditions, encountered particularly in marine service. This improvement is made possible by a special assembly, which lends itself more readily to moisture-proofing. The standard petal-shaped brass contact washer and pressure-limiting fibre washer are not used. Instead a single metal washer is employed, making it possible to apply the protective coating to all exposed surfaces.

Production of this special type of rectifier for the armed services is already under way, according to Mr. Scudder, and will be turned to the filling of commercial needs following the war. Manufactured by the *Federal Telephone and Radio Corp.,* 67 Broad St., N. Y.

TANDEM CONTROLS

A plurality of circuits—up to two dozen if desired—can be controlled by the single shaft of the "42" Series Control developed by *Clarostat Mfg. Co.,* Inc., 285-7 N. 6th St., Brooklyn, N. Y.

This new control was developed to



meet certain radio and electronic requirements calling for the single control of several circuits. To produce maximum rigidity in such tandem assemblies, as well as positive rotation of all units without the slighest backlash, the "42" Series construction has been worked out.

"42" Series Controls are necessarily made on special order only, since the number of sections and the values vary from one application to another. Units with as much as 20 sections are being produced for critical applications. Manufactured by the *Clarostat Mfg. Co.,* 285-7 N. 6th St., Brooklyn, N. Y.

NEW TIME-DELAY RELAY

A new time-delay relay, specifically designed for aircraft applications where time-delay drop-out is required, has been announced by the *General Electric Company.* It is available in two sizes, one providing up to 0.4 second time delay, and the other up to 0.3 second time delay. On many applications, this relay can be used directly to control the desired device, while on others it may be desirable to have the relay actuate a contactor.

Designed for use in a wide range of ambient temperature—from plus 95° C to minus 40° C—both sizes are compact, suitable for mounting in an position, and corrosion proof, withstanding 95 per cent humidity at 75° C on 48-hour test and operating successfully immediately thereafter.

The normally closed, double-break, silver contacts of the relays will carry 20 amperes continuously at altitudes up to 40,000 feet above sea level. Also, the operating coils can be furnished for operation on either a 12- or a 24-volt circuit. Mfg. by the *General Electric Co.,* Schenectady, N. Y.

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VARIABLE INDUCTORS

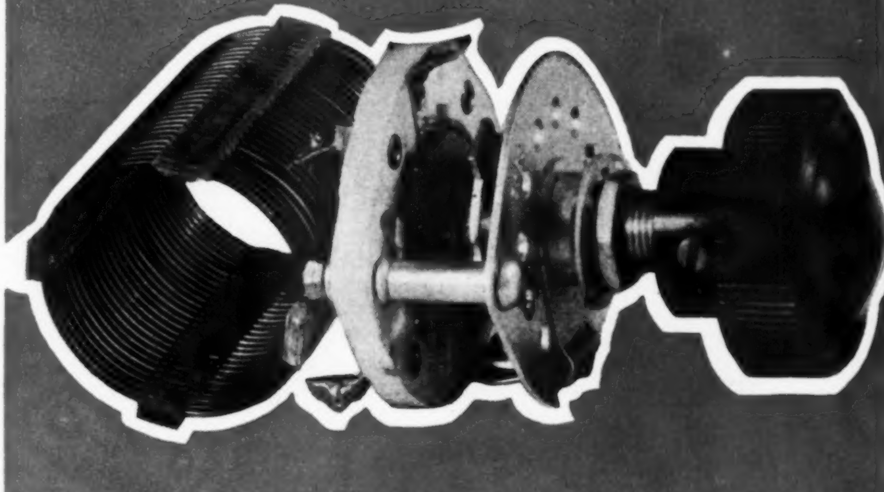


Fig. 3. Rotary switch used to vary the inductance of the coil.

by GUY DEXTER

A study of variable inductance coils and their characteristics. Present shortages of tuning condensers point toward the use of these inductors in tuning circuits.

PRESENT shortages of equipment are taking us back to the ingenious earlier days of radio when experimenters, having less manufactured apparatus available at reasonable prices, devised satisfactory means for getting along without certain essentials. Added theoretical knowledge, amassed over almost two decades of radio progress, should bring forth a grade of ingenuity today superior to anything seen in the early days.

One very real present problem is the result of a growing shortage of variable condensers. The variable condenser long since supplanted other instruments for tuning radio circuits, and has become so firmly entrenched in modern circuit design that many technicians have almost entirely forgotten the L-C circuit in which capacitance is fixed and inductance variable.

The reasons for universal adoption of the variable condenser for tuning radio circuits were entirely logical. It is a compact, smooth-acting instrument in which considerable range of adjustment may be incorporated. As an air-dielectric device, its figure of merit may be maintained at a high value, and it is relatively simple in design in any of its many forms. At the same time, it lends itself admirably to ganged arrangements for single-dial control. These are paramount factors in modern design. But now that variable condensers are sorely needed for the armed communication and development services and the ci-

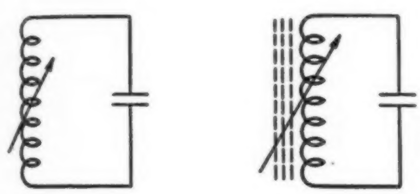


Fig. 1. Variable inductor symbols.

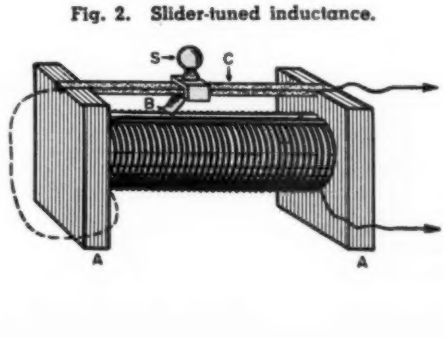
vilian supply grows slimmer, private experimentation can continue only if other means are embraced for the tuning of radio and radionic circuits.

The variable inductance offers a solution to the tuned circuit problem, an effective solution at that. There are several well-known methods of varying the inductance of a coil. Some are more adaptable to certain applications than others. All are effective. In general, it may be stated that any radio or radionic circuit normally tuned by means of a variable condenser may as readily be tuned over the same, or very nearly the same, range by means of a variable inductor, provided the designer selects the most efficient system for his particular application and provided, in some cases, that a somewhat reduced circuit Q may be tolerated.

In this article, there will be described several proven methods of constructing variable inductors. Actual tested examples will be presented. The writer has set up a series of these coils expressly for treatment on these pages, and has performed those measurements which will establish the characteristics and relative merits of each type. Either of these coils may be employed in conjunction with a shunt-connected condenser to form a tuned circuit. There are many possible variations, electrical and mechanical, of each design, and the reader may make free use of his own ingenuity in applying these units to his individual needs.

Perhaps, it should be stated in the beginning that the variable inductor is no innovation. Many of the radio transmitters used during World War I and shortly thereafter employed tuned coils of one sort or another. And several commercial transmitters of comparatively recent design still incorporate them. Also, we have seen the re-introduction of the variable inductor into broadcast receiver tuned circuits, since 1935, in the form of coils tuned by means of powdered-iron cores.

Fig. 2. Slider-tuned inductance.



Variable inductor circuits are represented by the symbols shown in Figure 1, which indicate the presence of variable L and fixed C. Symbol A specifically designates a circuit in which the coil is varied in inductive value by some adjustment upon its number of turns or the inductive relation of its separate parts. Symbol B specifically designates a circuit in which the inductance is varied by means of some external component, such as a metallic slug or powdered-iron core, moved within the field of the coil. In either of these arrangements, the fixed condenser may be of the air dielectric type or may embody some solid dielectric. However, in order to keep the circuit Q as high as possible, mica condensers are universally employed in the absence of air-tuned units.

Types

Of the several well-known types of variable inductors well known to radio technicians, the writer selected for test: (1) the slide-tuned coil, (2) tapped coil, (3) variometer, (4) powdered iron-core-tuned coil, (5) metal-slug-tuned coil, (6) metal-disc-tuned

coil, (7) shield-tuned coil, and (8) metal-ring-tuned coil. These particular types were chosen because they may readily be duplicated with simple tools by any experimenter. Considerable latitude is possible in adapting any of these types to individual applications of tuned circuits.

Slide Tuner

The slider-tuned inductance is perhaps one of the oldest practical variable inductor. Its history dates back to the electrolytic and crystal detectors and early *soft* tubes. It is based upon the simple principle of varying the number of turns in the circuit by selecting a desired portion of the coil by means of a sliding blade-type con-

Fig. 4. The variometer.

tact. This type of variable inductor is shown in Figure 2.

The coil itself is wound, preferably with enamelled wire, closewound on an insulating form of bakelite, polystyrene, fiber, cardboard, or ceramic. The coil L is supported between insulating end supports, A-A, to which is

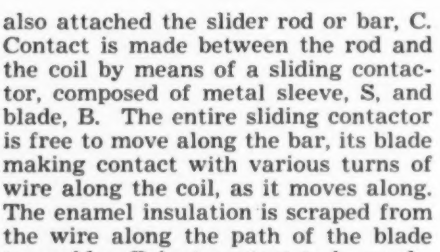


Fig. 5. Symbols used for variometer.

also attached the slider rod or bar, C. Contact is made between the rod and the coil by means of a sliding contactor, composed of metal sleeve, S, and blade, B. The entire sliding contactor is free to move along the bar, its blade making contact with various turns of wire along the coil, as it moves along. The enamel insulation is scraped from the wire along the path of the blade to enable efficient contact to be made.

One side of the circuit is connected to the slider bar; the other side to the end of the coil (either end). Thus, it is seen that the actual amount of coil connected into the circuit is chosen by appropriately setting the sliding contact. The inductive value may be varied between that of a single turn and that of all the turns in the coil.

Actually, this wide range of induc-

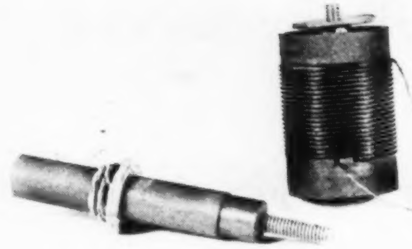


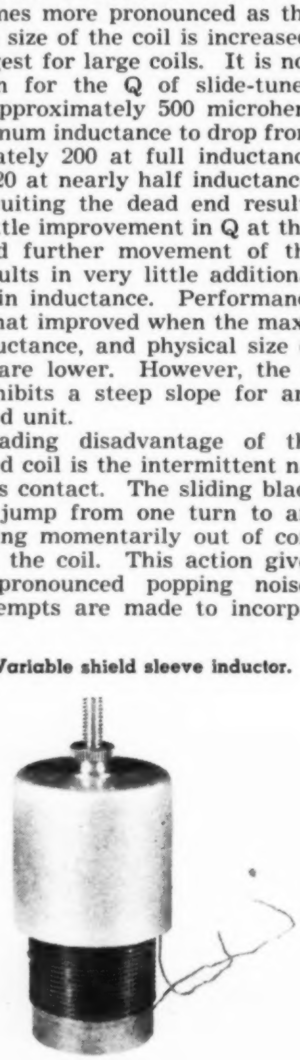
Fig. 6. Iron-cored inductors.

tance is not obtained in practice because a considerable portion of the coil remaining unused is still in inductive relation with the used portion. This is known as *end effect*. The dead end acts to alter the inductance of the active portion of the coil, limiting the practical reduction of inductance. Somewhat better performance may be obtained by connecting the end of the unused portion of the coil to the open end of the slider bar to short-circuit the dead end, as shown by the broken line in Fig. 2. However, only a slight advantage is gained by this modification.

The dead end acts to reduce the Q of the slide-tuned coil drastically as its inductance is decreased. This effect becomes more pronounced as the maximum size of the coil is increased, being largest for large coils. It is not uncommon for the Q of slide-tuned coils of approximately 500 microhenries maximum inductance to drop from approximately 200 at full inductance to about 20 at nearly half inductance. Short-circuiting the dead end results in very little improvement in Q at this point, and further movement of the slider results in very little additional decrease in inductance. Performance is somewhat improved when the maximum inductance, and physical size of the coil, are lower. However, the Q curve exhibits a steep slope for any slide-tuned unit.

The leading disadvantage of the slide-tuned coil is the intermittent nature of its contact. The sliding blade tends to jump from one turn to another, being momentarily out of contact with the coil. This action gives rise to pronounced popping noises when attempts are made to incorpo-

Fig. 7. Variable shield sleeve inductor.



rate the slide-tuned coil in tube receiver circuits, and was chiefly responsible for the demise of its popularity when the crystal detector was abandoned. In transmitter tank circuits, where large values of radio-frequency current flow, this intermittent contact gives rise to heavy sparking which eventually wears away both the contact blade and the coil turns. In a number of experimental circuits, however, where the declining Q value and limited inductance variation may be tolerated, the slide-tuned coil offers a simple solution to tuning.

Tapped Coil

Very similar to the slide-tuned coil is the tapped coil, illustrated in Figure 3. In this unit, a rotary switch takes the place of the sliding contact blade. The coil is wound with insulated wire, taps being brought out at appropriate points, in order that the switch may select various inductive

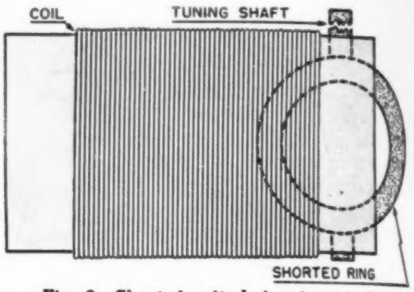


Fig. 8. Short-circuited ring type tuning.

values. In this type, as with the slide tuner, the actual coil size is adjusted.

The tapped coil, like the previously described type, possesses a Q curve that falls with decreasing inductance, however, the slope is not as steep as in the case of the slide tuner. The effect is particularly pronounced when the maximum inductance and physical dimensions of the coil are large. Nor is the effect reduced appreciably in large coils by shorting out the dead end. The most satisfactory and efficient tapped coils have low values of maximum inductance and small physical dimensions. However, these small coils are apt to be employed at high frequencies where switch contact resistance and other losses are apt to introduce additional difficulties to offset any advantage afforded by small size.

The following data was taken with a small tapped, air-wound coil. (Fig. 3): Full Coil; Q 278, L 0.014 mh. Three-Quarters Coil (Open Dead End); Q 280, L 0.013 mh. Three-Quarters Coil (Shorted Dead End); Q 238 L 0.0125 mh. Half Coil (Open Dead End); Q 205, L 0.0045 mh. Half Coil (Shorted Dead End); Q 173, L 0.0050 mh. One-Quarter Coil (Open Dead End); Q 188, L 0.0030 mh. One-Quarter Coil (Shorted Dead End); Q 161, L 0.0036 mh.

Like the slide tuner, the tapped coil introduces noisy operation in tube circuits, although this effect may be reduced somewhat by employing a wide

(*Continued on page* 82)

Electronic Measurements

(Continued from page 29)

Figure 4. Values in this illustration correspond to action of a self-generating cell with output of 450 microamperes per lumen. If such a cell is employed in the circuit of Figure 2 with a 0-1 d.c. milliammeter (average meter resistance of 33 ohms), response intermediate between the 3-ohm and 100-ohm curves will be obtained at 1000 microamperes (1 milliampere). Full-scale deflection will thus correspond to approximately 140 foot-candles.

When extremely small values of illumination are to be measured, a d.c. amplifier (such as shown in Figure 1) may be interposed between the photo-cell and the indicating meter to provide higher sensitivity.

Aside from measuring actual illumination values as such, light meters have been employed in industry to determine the turbidity, and in some cases color of solutions to measure smoke density in stack and furnace control, and to measure the degree of surface polish in certain materials in terms of reflected light. It has also been employed in the testing, calibration, or adjustment of light-generating devices in line of production.

Thickness of Non-Conducting Materials

The thickness of non-conducting materials, such as paper, cellophane, and other sheet stock, may be determined by a double oscillator circuit, either continuously, as when the material is being automatically wound upon spools, or intermittently, as in sample testing. An arrangement for accomplishing this measurement is shown in Figure 5.

The apparatus includes a variable-frequency r.f. oscillator, a fixed-frequency r.f. oscillator, a mixer-audio amplifier circuit, and a beat-note indicator such as an audio frequency meter. In parallel with the frequency-determining L-C circuit of the variable-frequency oscillator is connected an external measuring circuit consisting of a two-element "measuring head." The head embraces two solid metallic members, a lower fixed electrode, over which the material passes in contact, and an upper movable electrode which rests upon the upper surface of the material but is free to move up and down as the thickness of the material changes. This measuring head is equivalent to an additional condenser, with the tested material as a dielectric, which is connected across the variable-oscillator tuned circuit.

As the material passes between the two electrodes of the measuring head, the changing capacitance will alter the frequency of the variable oscillator. If the fixed oscillator frequency is maintained near that of the variable oscillator, a beat note is set up and this is demodulated, amplified, and presented to the beat-note meter. Obviously, the capacitance of the measuring head will depend not only upon the thickness of the material between its electrodes, but likewise upon the dielectric constant of that material. However, for a given material of uniform quality, the dielectric constant may be maintained fairly constant, so that the varying beat note, as the material passes through the measuring head, will depend most upon the amount of separation of the electrodes.

In operation, the material is fed into the measuring head, the portion actually resting between the electrodes being of the desired thickness. The variable oscillator is then set to zero beat with the fixed oscillator, whereupon the indicator reads zero. The material is then permitted to pass through the head, any change in its thickness causing a decrease in the head capacitance, a corresponding shift in the beat-note frequency, and a deflection of the meter. The meter may thus be graduated directly in thousandths of an inch or any other appropriate unit of measure.

Very often it is desired to show both plus and minus variations in thickness—that is, increases and decreases about a desired thickness. This may be accomplished by setting the beat frequency in the beginning to a value at mid-scale on the meter, rather than to zero beat. An increase in measuring-head capacitance will then cause an up-scale meter deflection, while a decrease in thickness will cause a down-scale deflection. The indicating meter may then be graduated in identical units of thickness on each side of a mid-scale zero, and the instrument will show whether the material is increasing or decreasing in thickness.

This same double-oscillator arrangement has been employed in other industrial measurements including the measurement of variations in dielectric constant of materials of uniform thickness, measurement of temperature coefficients of various conductors which are made a part of the measuring-head electrode assembly, and the determination of small weights. In the latter application, the lower electrode of the measuring head is rigidly mounted, while the upper electrode is supported by springs and is provided with a weighing pan. Increases in weight accordingly decrease the head-electrode spacing, increasing the capacitance of the assembly. By using a frequency indicator capable of showing a change of only a few cycles per second, and by employing highly-stable r.f. oscillators, weights and thicknesses of very small orders of magnitude have been successfully measured in industry. A few millionths of an inch has thus been detected.

Detection of Metal Particles and Small Holes

In the manufacture of certain insulating materials, such as condenser paper, insulating cloths and papers, and the like, the presence of small


ELECTRONIC
VOLTMETER
OHMMETER

particles of metal in the material must be detected in routine inspection. These particles are very often so small as to be invisible to the eye of the inspector, or may be imbedded within the material.

An arrangement similar to the double-oscillator circuit of Figure 5 has been employed for this purpose. The presence of metallic particles in material of varying thickness (which passes between, but not in contact with the measuring-head electrodes) will cause abrupt changes in the meter deflection.

A simpler arrangement has also been employed. A radio-frequency detector circuit is set up near the passing material in such a manner that the material must pass very close to the frequency-determining coil. The circuit is usually adjusted to be on the verge of oscillation, so that the presence of a metallic particle will set the circuit into oscillation, trigger-fashion.

Opaque or dense translucent materials may be inspected for pinholes by means of a light source, photocell, and alarm circuit. The light source delivers a narrow beam which sweeps the material as it passes through processing machinery. The photocell is located on the opposite side of the material and is connected to an amplifier and a suitable alarm device, such as a bell, horn, or light. When a pinhole is located, the beam impinges upon the cell, setting off the alarm. By employing a rapid beam sweep and fast-acting cell, a maximum of area may be inspected as the material passes at a normal rate of speed.

This system is not so readily applicable to less dense translucent materials and may not be adapted at all to transparent materials such as celluloid, cellophane, etc. With dense materals, however, tiny apertures may be readily detected by employing a highly-sensitive photocell alarm circuit. For less dense materials, the sensitivity may be reduced somewhat by means of an appropriate gain control so that the alarm circuit will not be actuated by light seepage through the material instead of by direct rays through holes.

Thickness of Surfacing

The thickness of various surfacing materials on metallic surfaces may be checked electronically when the material is not readily checked by means of micrometers and similar gauges. An example is the thickness of paint or other insulating or protecting materials upon metal plates of large size.

The coated plate is made one electrode of a fixed condenser which is then connected in a suitable capacitance-measuring circuit of either the vacuum-tube, meter, or bridge type. A second exploring electrode, constructed of flatly-polished metal, is pressed tightly against the coated surface. From the active area of the exploring electrode, which is also connected to the measuring circuit, and the dielectric constant of the coating material, together with the capacitance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obtained by measurement, the thickness may be calculated: $t = kA/4.45C$; where t is thickness (inches), k is dielectric constant, A is area of exploring electrode (square inches), and C is measured capacitance (micro-microfarads).

The success of this measurement depends upon obtaining a tight bond between the exploring electrode and the surface of the coating material, in order to eliminate as much air dielectric as possible, and upon the maintenance of the shortest possible leads to the measuring instrument. The method may not be applied to surfaces having conductive properties.

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Color Comparators
(*Continued from page* 41)

regions are selected for measurement from the complex waveform and a measurement is made separately in each band of light reflected from the sample. The three readings give a complete account of the color.

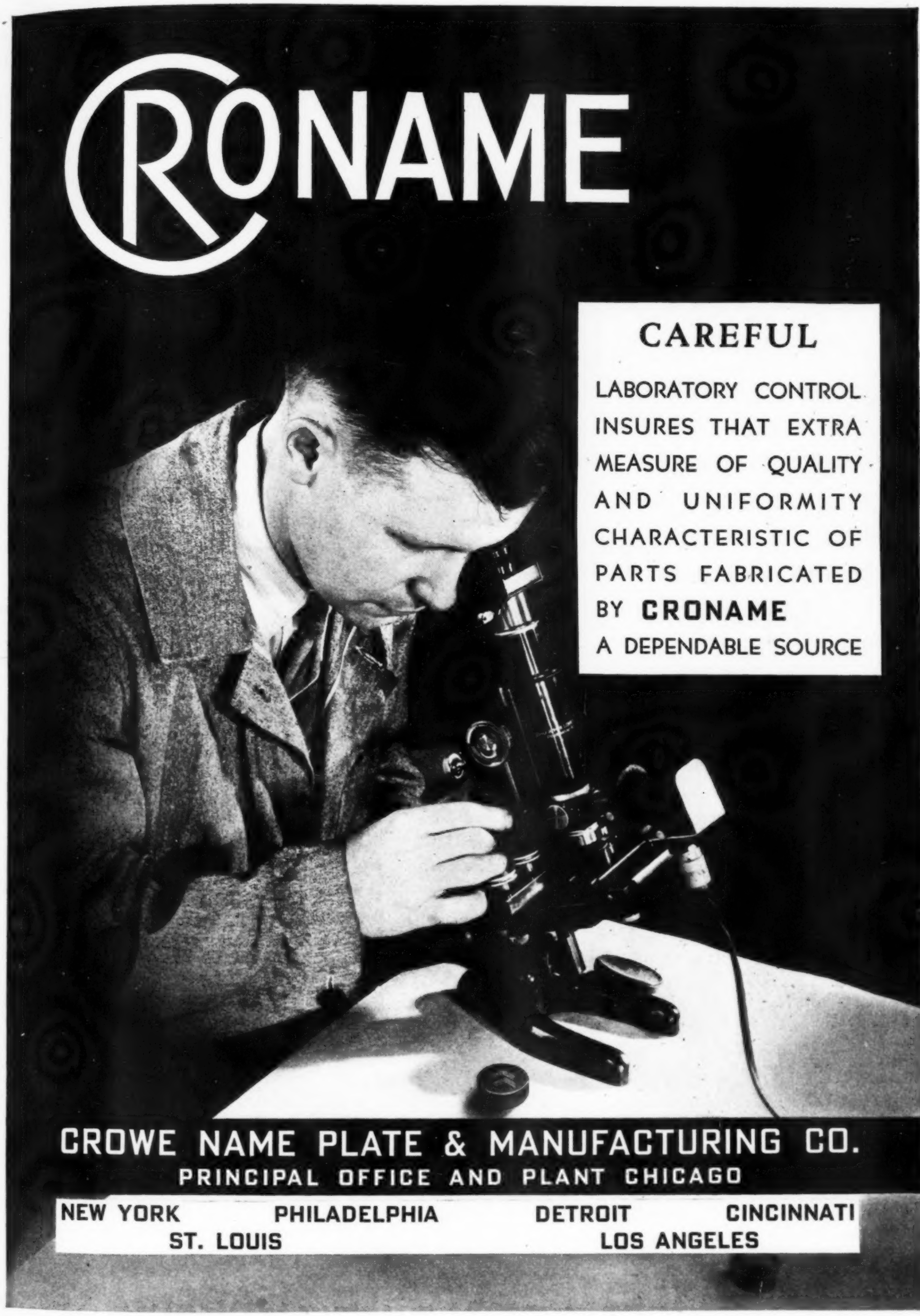
The lamp at the bottom of the chamber is energized by the constant output of a voltage regulator. The light it produces passes through a lens system, one of the three color filters, the open center of the light-sensitive surface, through the viewing aperture, and strikes the test sample. The latter is "slightly out of focus" so as to receive diffused illumination over a relatively large area. The filtered light is reflected by the surface of the test sample to the light-sensitive surface which is so constructed as to integrate light arriving from a number of directions.

Separate meter readings are taken with the red, blue, and green filters in place. Two colors match precisely in hue, saturation, and brilliance when the meter deflections obtained successively with red, blue, and green filters are the same for the two samples.

In operation, the instrument is first standardized with a calibration sample of magnesium oxide, a white material; with the magnesia sample over the viewing aperture, meter shunts are adjusted for a reference deflection of the meter with red, blue, and green filters successively in place. Readings with each filter may then be taken with the test sample over the viewing aperture.

Still finer color inspection is possible by analyzing separately each of the components in a complex color waveform, evaluating each in terms of some satisfactory unit of intensity. A color analyzer for carrying out such an inspection has been designed by Hardy and manufactured by General Electric Company.

This instrument is comparable to the wave analyzer employed by radio engineers to explore a complex audio-frequency waveform and performs in an analogous fashion. The high degree of selectivity required for "tuning" to the various color wavelengths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is provided by sharply-tunable optical filters.

The separate adjustments to individual wavelength components required in operating the color analyzer, and the time required to make these numerous settings make the analyzer unsuitable for rapid production tests such as color matching. And, for the latter type of inspection, the simple color comparator is highly satisfactory. The analogous condition is encountered at lower frequencies, where simpler distortion meters supplant the more complex audio wave analyzer for routine production operations demanding speed and economy with a minimum of operating skill.

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Army's SCR-299

(Continued from page 20)

found the 299 in trucks, fixed stations, and in other units which were broken down into components so that they could be flown over the "hump" (of the Himalayas) for use by our Air Forces in China under General Chenault. In fact, the General saw two of the SCR-299's being unloaded as his plane landed in China.

American radio engineers and military personnel will be interested to note some of the remarks made by various commands on this Signal Corps radio unit and its application. The SCR-299 was used on five networks at the time our huge convoy landed in North Africa. These included circuits from Oran to England, Casablanca, Gibraltar, Algiers, and Accra.

General Olmstead, in a recent interview, said, "This set was picked as being oustanding because it performed admirably in applications other than those for which it was originally designed. It possesses much versatility and is so popular that the main difficulty is increasing orders to meet the demands from the various forces.

"The generator which goes along with the set in the trailer unit provides adequate power. We have seen cases where unusually long periods of continuous operating service have been had without failure."

Comments from a report made by Lieutenant Colonel A. A. McCrary, at a location which cannot be revealed, included the statement:

"The SCR-299 is a great set," by the Army Signal Corps Officer, 5th Army in North Africa.

Commanding General of one of the Infantry Divisions on the African front said: "It's a good set."

From the Commanding General of the 34th Division comes a report, "It is a mighty fine set. We have about all we need in this section."

The Chief of Staff of the 1st Armored Division has the following comment: "The 299 is a fine set. This set will give us all the range we need and more. Of course, at times we run into heavy static and can't get through—but no radio set would under those conditions."

In another report, the Signal Corps Officer of one of the Base Sections says the following: "The SCR-299 has been installed as a fixed radio station and is giving excellent results."

The Signal Corps Officer of the 1st Armored Corps, in a recent report included the following: "The 299 was used for a fixed point installation. It is an excellent set, very stable, and gives the necessary frequency range."

Major Pickett, prominent field officer, reports: "The 299 is a fine set and is giving excellent results."

These are only a few quotations from official reports. Military censorship does not permit any vital information to be released which would be of aid or comfort to our enemies. Therefore, until other battles are won and campaigns are completed, we cannot give "case histories" from other fighting fronts where this unit is giving superb service and where it is helping to win further "battles of communications!"

The American radio industry can well be proud that it and the Signal Corps have contributed an outstanding development comparable to that of the Flying Fortress, the Liberator, the Garand rifle, the "jeep" and the many other potent weapons which will inevitably aid in winning total Victory.

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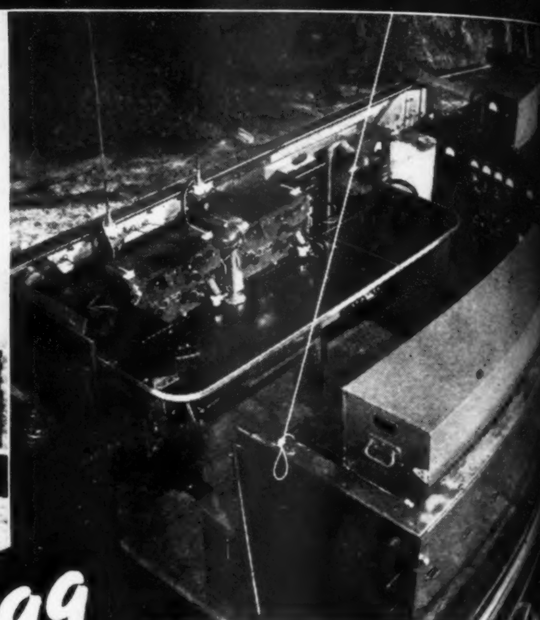

SCR-299

Mobile communications units assembled by Hallicrafters are helping to win the battle of communications on every fighting front. They are built to endure the rigors of modern warfare . . . The consistent performance of SCR-299 has been highly praised by lead-

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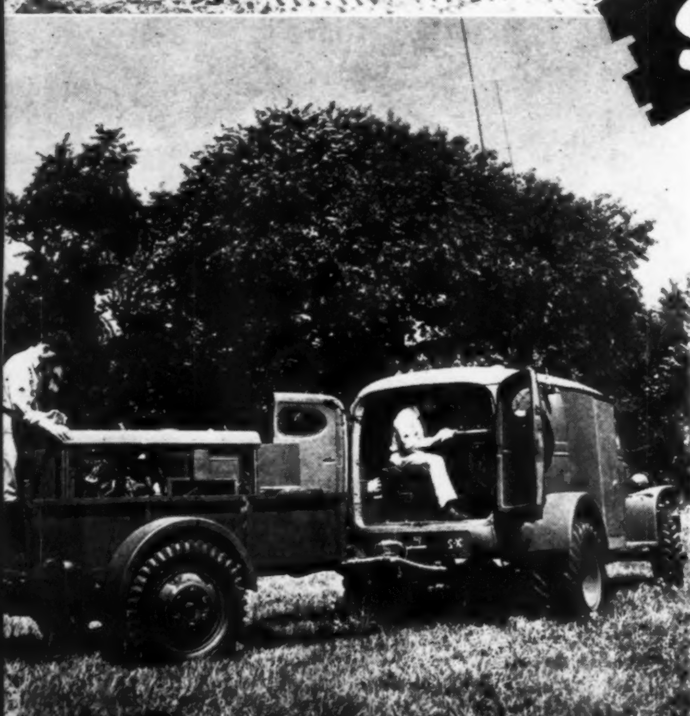

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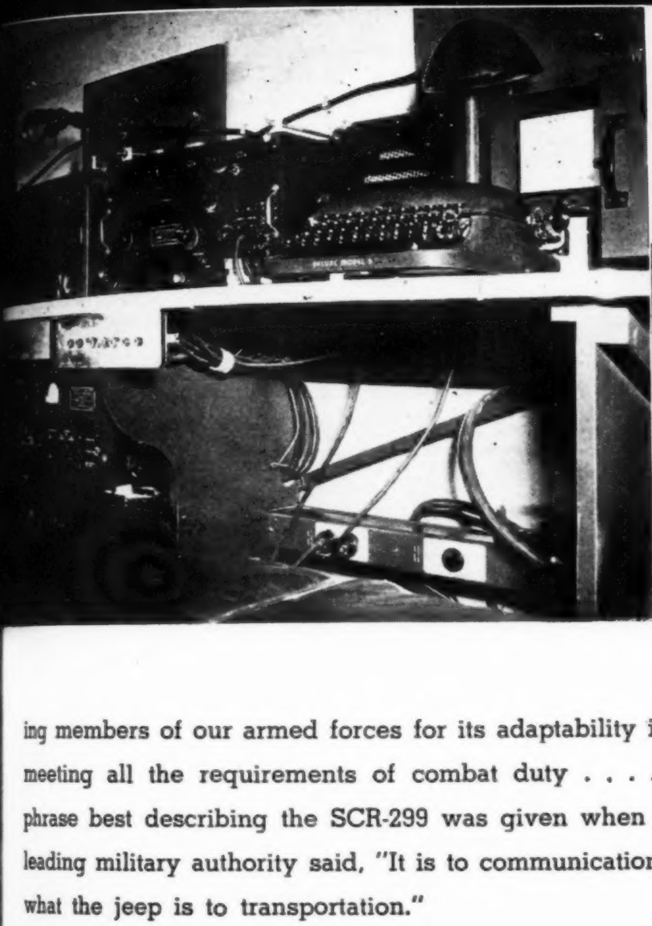

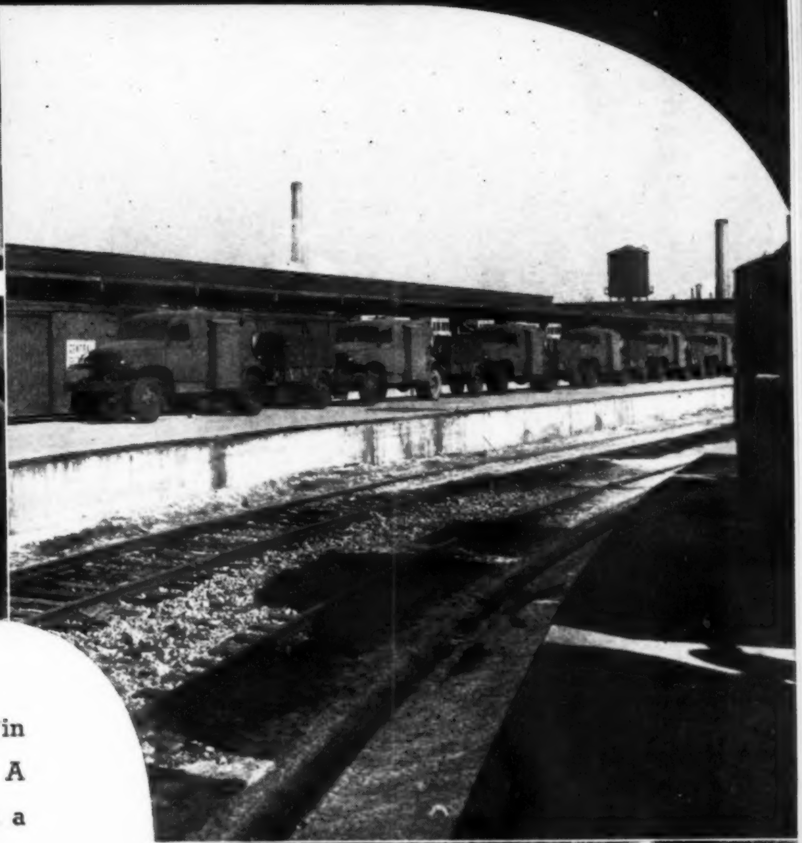

ing members of our armed forces for its adaptability in meeting all the requirements of combat duty . . . A phrase best describing the SCR-299 was given when a leading military authority said, "It is to communications what the jeep is to transportation."

afters
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ARMY E NAVY

BUY MORE BONDS!

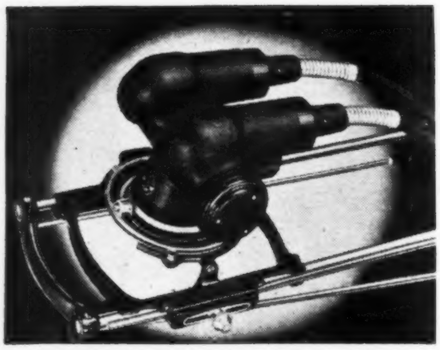
OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT

Medical Apparatus
(*Continued from page* 36)

platinum needle that may be brought in contact with tissue. The extremely high current intensity at the point of needle contact is so great that considerable heat is produced and the tissue may be entirely destroyed. Small blood vessels, severed by such means during operations, are sealed normally by the heating action and considerable reduction in loss of blood is the result. There is no essential difference between the radio knife and diathermy equipment.

Above 10,000 cycles per second, the human being experiences only a sensation of heat when an electric current is passed through the body or parts of it. The value of current that the average person can stand at 60 cycles ranges from 3 to 10 milliamperes. At 10,000 cycles it may extend from 25 to 30 milliamperes, at 100 kc. it may range from 250-600 milliamperes. The frequencies widely used are 500 kc. to 1,000 kc. Diathermy apparatus must be licensed under new regulations of the government since such equipment can easily be converted into powerful sending apparatus. Its use in radio transmission is, of course, strictly forbidden.

Electrodes a couple of square inches in size are used to apply the treatment to an area uniformly. In clinical machines the patient may be placed in an electromagnetic field created by a powerful apparatus. It has been found that such treatment is beneficial in cases of syphilis, pleurisy and many other diseases.


A Coolidge oil-immersed X-ray tube.

Types of High Frequency Medical Generators

The old spark coil transmitter used in the early days of radio represents one type and the other is a standard tube oscillator arrangement. In one type of diathermy apparatus a small spark coil is mounted in a bakelite handle and electrodes of various sizes and shapes may be fitted into the end of the handle. Holding the handle in one hand, the electrode is touched to the body and then drawn off slowly. It is found that a bluish light is observed and a sort of spitting, hissing noise is heard. The output of this type is varied by adjustment of the speed of the vibrator which is done by twisting a knob on the handle to the right or left depending on whether an increase or decrease is desired.

The usual service troubles that develop are: shorted or leaky condenser across the vibrator-contacts, open coil, broken leads or connections, dirty or pitted vibrator points which can be cleaned in much the same way as the interruptor of a car ignition circuit, or the contacts of a relay. The output of such a device may carry over a wide band of frequencies similar to a car's ignition system, having no tuned elements. In more elaborate apparatus tuned circuits may be used and the equipment is more bulky. Typical circuits are shown in Fig. 4.

The use of radio and electrical apparatus by men of medicine is continually increasing. The audiometer used in connection with fitting of hearing aids to deaf persons, the electrocardiograph for making a record of heart action, the encephalograph recently developed by Dr. Saxton Burr of Yale which permits measurement of brain currents and many other similar uses of electricity bid fair to make the world of tomorrow even more interesting and of greater scientific achievement than in the past.

—30—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Practical Radio Course
(*Continued from page* 39)

harmonics is present, as we shall see later.

Conditions for Maximum Power Output

In order to analyze the operation of a power tube and ascertain the maximum power output obtainable (without regard to any distortion that may be produced) it is convenient to consider the typical output circuit shown at (A) of Fig. 4. Its equivalent electrical circuit is illustrated at (B). The power tube is shown supplying signal power to a load in its plate circuit when a signal voltage having an "effective" or r.m.s. value of e_g is applied to its grid circuit. While the load may be any kind of device to be actuated, in this case it is represented as the primary winding of an output transformer feeding a loudspeaker. In the equivalent electrical circuit shown at (B) the r.m.s. signal voltage acting on the grid is replaced by the a.c. signal generator whose voltage is acting directly in the plate circuit; where μ is the amplification factor of the tube. The internal a.c. plate resistance of the tube is shown as R_p and the impedance of the plate circuit load is R_L.

The amplitudes of the current changes in the plate circuit are equal to the amplified voltage changes (μe_g) acting in the plate circuit divided by the total resistance and impedance in the plate circuit, thus:

$$I_p \text{ (change)} = \frac{\mu e_g}{R_L + R_p}$$

This varying current I_p flowing through the load resistance R_L produces a change of voltage E_L acting across the load resistance, or

$$E_L = I_p R_L$$

Substituting the value I_p in the previous equation for I_p in the foregoing equation we obtain:

$$E_L = \frac{\mu e_g}{R_L + R_p} \times R_L = \frac{\mu e_g R_L}{R_L + R_p}$$

The power in watts ($P = E \times I$) expended in the load impedance (considered as resistive) is equal therefore to the product of the r.m.s. values of this current and voltage. Hence the power output is:

$$\text{Power Output} = \frac{\mu e_g}{R_L + R_p} \times \frac{\mu e_g R_L}{R_L + R_p} = \frac{R_L \mu^2 e_g^2}{(R_L + R_p)^2}$$

This equation is fundamental for all vacuum tubes, assuming the tube to be operating on the straight part of its characteristic; i.e., that the plate and grid voltages are properly adjusted.

The *power output* for any given sig-

nal input voltage is a *maximum* when the a.c. plate resistance R_p and the load resistance are equal (that is, when $R_p = R_L$)*. For example, a type 45 triode power amplifier tube which has an a.c. plate resistance R_p of 1,750 ohms will supply *maximum* power output for any given input signal voltage when the load resistance R_L is also 1,750 ohms. Under this special circuit condition, the power output equation just derived reduces to:

$$\text{Maximum Power Output} = \frac{\mu^2 e_g^2}{4R_p} = \frac{(\mu e_g)^2}{4R_p}$$

If this equation is to be expressed in terms of *peak* signal voltages, then remembering that the effective or r.m.s. value of a voltage or current equals 0.707 times the maximum or peak value, or equals the maximum value *divided* by the square root of 2, the expression becomes:

$$\text{Maximum Power Output} = \frac{(\mu E_g)^2}{8R_p}$$

where the *Maximum Power Output* is that obtainable when a signal voltage having a peak value of E_g is applied to the grid circuit of the tube.

This equation shows that the maximum output obtainable from a power tube depends not only upon the mu (μ) and a.c. plate resistance of the tube, but also upon the magnitude of the a.c. signal voltage applied to its grid circuit. This, of course, demonstrates the necessity for the use of *voltage* amplifiers ahead of the power amplifier to build up the signal voltage before it is applied to the control grid of the power tube.

Since it is desired to obtain from a power amplifier tube the greatest possible amount of *undistorted* signal power output for a given applied signal voltage, it is convenient to compare the merits of power tubes on the basis of the relationship between power output and input signal voltage. This relationship is called the *power sensitivity* of the tube.

$$\text{Power sensitivity } (mhos) = \frac{\text{power output (watts)}}{(\text{r.m.s. input signal volts})^2}$$

Thus, a power tube delivering 8 watts output when an input signal of 10 volts r.m.s. is applied, has a power sensitivity of $\frac{8}{10^2} = \frac{8}{100} = 0.08$ mhos.

In general, pentode type power amplifier tubes have a much greater power sensitivity than do triodes. For example, when the 6L6 tube is operated as a pentode (strictly speaking, it is a screen grid tetrode so designed that the secondary emission is suppressed so it operates like a pentode), it consumes about 22 watts in its plate and screen circuit and, with a 14-volt signal applied to its grid, delivers 6.5 watts to the load. Now, when the screen is tied to the plate the tube becomes a triode. When so connected and the same value of plate voltage is applied, the 6L6 tube uses 10 watts in its plate circuit and, with a 20 volt signal applied to its grid, delivers only 1.4 watts. Even though the triode arrangement consumes but half as much power in the plate circuit, it requires about ⅓ more signal voltage to produce less than 25% as much signal power output. In other words, a pentode-connected 6L6 tube when employed in proper circuits will deliver more than four times as much power to the load with a signal voltage only ⅔ as great as required by the same 6L6 tube connected as a triode. This simply means that the power amplifier pentode tube has a greater power sensitivity than the triode. The practical advantage is that less voltage amplification is required preceding a power amplifier tube having high power sensitivity since it does not require as much input signal voltage for a given signal power output. Of course, other considerations such as allowable distortion, etc., might overbalance this advantage of the pentode for some applications.

* For a mathematical proof of this, see any textbook on the fundamentals of radio, such as the author's Radio Physics Course.

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They work together better . . .
because they can talk together

The streaking
Reconnaissance plane
Can't wait
Until its wheels touch
The lifting flat top
To tell its news . . .

While still
Only a growing shape
Over the horizon
This homing eagle
Calls to the mother ship . . .
Summons its brother warbirds
To the kill . . .
By radio.

In a matter of minutes
The whole angry brood
Will swarm down
And polish off
The fleeing cruiser that
Just a few seconds before
Was a threat
To our bridge of ships . . .

Seconds count
In this thundering war
Of time and teamwork . . .
And seconds are saved
By the radiotelephone.

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War by Radio
(Continued from page 37)

drew a picture of future battles where squadrons of tanks would roar into the attack, guns blazing, without crews. They would be controlled by wireless by operators in remote control dugouts far from the scene of battle. Television would enable the operators to follow the course of the battle and alter their tactics accordingly.

Lord Birkenhead's predictions were not based on fantasy. Shortly after the last war the Great Powers had begun experimentation in *telearchics*—the remote control of mechanisms by wireless. The strides made in this field have been phenomenal.

As early as 1939 flights of more than a hundred miles had been made in the United States without the hand of a human pilot touching the controls. In France small planes went through complicated maneuvers guided entirely by wireless from the ground. It was a step from the use of the Sperry gyroscopic stabilizer — "automatic pilots"—to the wireless operation of the automatic pilot from the ground.

In 1935, the wireless-controlled Queen Bee, flying at more than 100 m.p.h., rising to a height of 10,000 ft., was introduced by the R.A.F. for gunnery practice. Seven white keys before the wireless operator on the ground was all that was manipulated in directing the plane. The "human factor" had been all but eliminated in flight.

The next step was obvious. If planes—and tanks and guns, for the principle of wireless control was the same in all cases—could be operated by remote control, why was it not possible for them to carry bombloads to targets, release them and fly back?

In September, 1940, Dr. Lee de Forest, brilliant American wireless experimenter, announced that a pilotless "television torpedo" plane was in the making. The plane would be made from plastics requiring no expensive armour-plating, as it would carry no personnel. Television cameras would be placed in the nose of the plane and a television transmitter would flash back to the control point a full picture of the changing scene as viewed from the plane. The operator could then maneuver the aircraft to perform its work of destruction.

Several months later, before America's entry into the war, American experts had achieved the pilotless bomber, a robot plane which could take off, fly to the target—the distance was limited only by the wireless frequency range and the fuel capacity of the aircraft—discharge its bombs and return to its base. For long-distance flights a fleet of robot planes could be "chaperoned" by a piloted aircraft which would control the movements of the robot squadron.

Meanwhile, wireless control of mechanized ground equipment, water craft, and artillery was rapidly being developed. Amateur experimenters, as always, made their valuable and distinctive contributions.

In New York I watched model ships maneuver into battle formation, aim their guns and fire at targets by remote control.

At the National Model Championship meeting held in Chicago in July, 1941, model aircraft went into power dives, pulled out, looped-the-loop and normally behaved as if they were being piloted by the most skillful of pilots.

A model plane climbed to 1,500 feet, power-dived to a few yards of the ground, climbed back in a steep ascent and went gracefully through a series of figures-of-eight before landing—all by remote control.

One of the chief problems confronting radio engineers in the development of wireless warfare was the interference which would be used by the enemy in frustrating our own wireless control.

Conceivably, enemy engineers would pit their wits against Allied design to "tangle" wireless controlled mechanisms. Highly complex mathematical battles could be fought over the radio waves for control of vast assemblies of robot tanks and aircraft operating in the No Man's Land of the ether.

MICAMOLD'S POSITIVE *Leak Detector*

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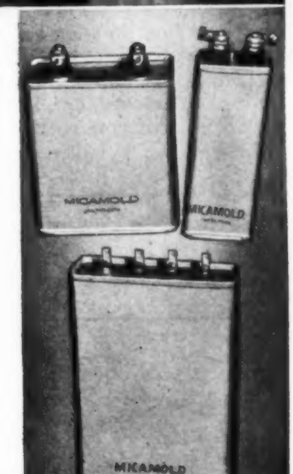

Manufacturers who use *Micamold Oil Impregnated Paper Capacitors* are assured that they are thoroughly leak-proofed at our factory. This is done by means of our *positive* "Leak Detector" . . . an ingenious silent watchman which definitely points out any leaks or defects. It must be "true" before it leaves the plant. *Micamold* dependability is a factor you cannot afford to overlook. Communicate immediately . . . and we'll send a representative to discuss your capacitor problems.

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- MOLDED WIRE WOUND RESISTORS
- OIL IMPREGNATED PAPER CAPACITORS
- RECEIVING AND TRANSMITTING MICA CAPACITORS

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This problem of interference has been tackled with considerable success, and the danger of radio-controlled mechanisms turning against their creators has been partly solved, although insurance against "Frankenstein" disasters must still be perfected.

The guidance of aircraft by the radio beam has long been an established fact. The landing of aircraft in all kinds of weather has reached a high stage of perfection since 1938, when the radio beam method was introduced in American aviation.

At that time Mr. Louis Johnson, Assistant Secretary of Air, said: "We will be able to take off and land under conditions of zero visibility. In all kinds of weather we will be able to use the flying machine both as a military weapon and as a commercial carrier. Today 50 per cent of all air accidents are attributed to bad weather. Tomorrow, with the aid of this new automatic device, we will go far toward the conquest of the fog and the storm and the elimination of the hazards that the hostile elements carry."

Tomorrow is here. The air is interlaced with invisible roadways of radio beams as definite as if they were made of concrete.

—30—

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Manufacturers' Literature

(*Continued from page 37*)

equipment in the field of operations.

This handy booklet includes color code information on resistors, condensers, power and audio transformers, IF transformers, and speaker lead and plug connections. An additional feature is a conversion table of fractional inches to decimal and millimeter equivalents.

Immediate shipment can be obtained on orders sent to *Allied Radio Corporation*, 833 West Jackson Boulevard, Chicago, Illinois.

RCA VICTOR ISSUES MORSE CODE ALBUM

A modern, streamlined system of instruction in the International Morse Code has been incorporated in a six-record album which Victor is releasing this week.

Prepared by John N. Cose, Director of Instruction at the *RCA Institutes*, the album and accompanying booklet are designed to acquaint students with the actual sound of the morse code letters as they would be sent over the air and to provide them with specially prepared practice transmissions which should develop the students' ability to copy regular code messages.

A novel feature of the morse code album is the incorporation of instructions on the records themselves, with the handbook as a check on all practice messages transmitted.

The first 8 lessons are devoted to alphabet instruction and special practice in letters introduced. Following intensive instruction and practice in the 26 letters, the album moves on to a study of coded five-letter groups, longer plain English words, sentence structure, "hard to memorize" English transmission, and winds up with a practice session of five-letter cipher groups using all the letters of the alphabet in unfamiliar combinations.

Vocal instruction disappears gradually throughout the album, leaving the last records almost completely devoted to code practice work. Two stumbling blocks in code instruction, memorization and anticipation of contents by the student, have been overcome by use of code and cipher groups which form unrecognizable words.

The war has created an unusual demand for code instruction, with the armed forces calling for trained signal men and the U. S. Signal Corps sponsoring training schools all over the country. The new Victor code album may be used as a valuable supplement to these code training courses.

GHIRARDI RADIO TROUBLESHOOTER'S HANDBOOK

The tremendous popularity of the *Ghirardi* Radio Troubleshooter's Handbook has made it necessary to bring out a revised and enlarged 744-page edition—the third—of this practical and authoritative volume. It is new—complete—vital—a veritable gold mine of profitable information helpful in all phases of radio service work and designed to enable both new and experienced technicians to troubleshoot and repair all types of radio receivers faster and for greater profit under present "wartime" emergency servicing conditions.

Featured among its 744 manual-sized (8½" x 11") pages now are 404 pages of trouble "Case Histories" giving all the common troubles and their remedies for over 4,280 receiver and automatic record changer models—the largest authoritative "Case History" compilation ever published; a complete tabulation of I-F peaks and alignment data for practically every known superhet receiver; the most complete tube characteristics and biasing data chart ever published anywhere.

This big new Revised Edition is bound in handsome wear-resisting blue cloth with a stiff cover specially designed to stand constant handling in the shop. To really appreciate its completeness and merit, every service man should examine a copy for himself—page by page. The price is $5 in the U.S.A. Copies may be obtained from your regular jobber or direct from Radio & Technical Publishing Co., 45 Astor Place, New York City, publishers of *"Ghirardi"* radio books.

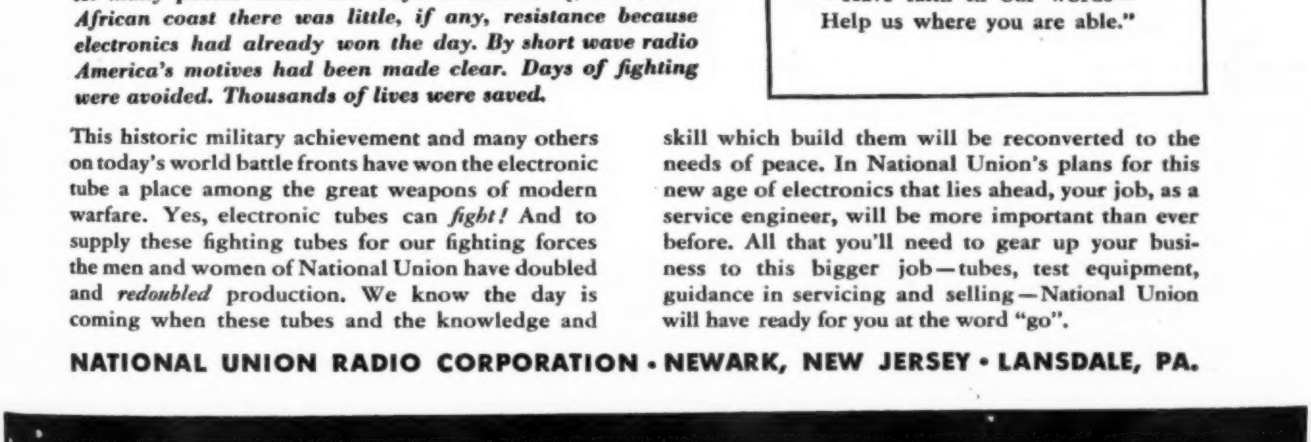
—30—

On Sunday, November 8, **in North Africa, the sound which broke the peaceful stillness of that eventful night was not the booming of allied guns, nor the throbbing engines of countless landing barges. It was a VOICE—the friendly voice of the President of the United States saying "We come among you to repulse the cruel invaders—Have faith in our words—Help us where you are able."**

At many points where our boys landed along the North African coast there was little, if any, resistance because electronics had already won the day. By short wave radio America's motives had been made clear. Days of fighting were avoided. Thousands of lives were saved.

This historic military achievement and many others on today's world battle fronts have won the electronic tube a place among the great weapons of modern warfare. Yes, electronic tubes can *fight!* And to supply these fighting tubes for our fighting forces the men and women of National Union have doubled and *redoubled* production. We know the day is coming when these tubes and the knowledge and skill which build them will be reconverted to the needs of peace. In National Union's plans for this new age of electronics that lies ahead, your job, as a service engineer, will be more important than ever before. All that you'll need to gear up your business to this bigger job—tubes, test equipment, guidance in servicing and selling—National Union will have ready for you at the word "go".

NATIONAL UNION RADIO CORPORATION • NEWARK, NEW JERSEY • LANSDALE, PA.



For the Record

(Continued from page 4)

As this device is capable of removing all types of interference from radio receivers, the chief advantage of FM would be that of obtaining a higher fidelity for musical programs—which brings us to the second question: how many people really appreciate so-called high fidelity? We have talked to many of our friends and associates in recent months and find that, in most cases, the average listener will always make use of the tone control to reduce the normal range of the higher frequencies.

The first loud-speakers were over-abundant in highs. In later years there appeared on the market large console receivers which possessed an over-abundance of bass. Most people welcomed these new sets and found the listening a bit more comfortable and less irritable.

As time went on, a happy medium was found for the reception of treble and bass frequencies and a more even balance was found in the better receivers. There still was a tendency, however, to accentuate the bass frequency by artificially reducing the treble. Even today most people prefer their sets to operate in that fashion. Many become irritated from the extreme high treble notes received on FM sets. We do not seek to discredit the advantages of FM. However, with the new static eliminator the broadcasters of AM will be assured that their programs will be received satisfactorily, even by rural listeners. Furthermore, the greater coverage of AM will still be an advantage over FM transmissions.

Only time will tell just how successfully this new system will work and how far it will go to satisfy postwar radio listeners!

HUNDREDS of complimentary letters are being received on the recent *Aviation Communications* issue of RADIO NEWS. A few of them appear on Page 95. We are proud to have been able to make such a contribution to the war effort by presenting the complete story on the part that radio is playing in making possible the huge bomber attacks on our enemies and to show the many branches of service and other organizations upon whom rests the responsibility of "getting the message thru."

WE are happy to announce the addition of Mr. K. R. Porter to our RADIO NEWS staff. Mr. Porter, now an accredited correspondent, has left this country for Europe where he will gather factual information on the part that radio plays in winning the battle of communications. Formerly affiliated with the Office of Technical Information, *Special Activities Branch* of the *U. S. Army Signal Corps*, Mr.

The SPRAGUE TRADING POST

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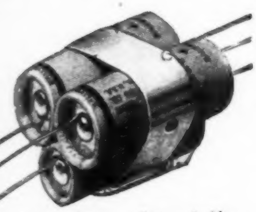
Your own ad run FREE!

The "Trading Post" is Sprague's way of helping radio servicemen obtain the parts and equipment they need, or dispose of the things they do not need during this period of wartime shortages. Send in your own ad today—to appear free of charge in this or one of the several other leading radio magazines on our list. Keep it short — WRITE CLEARLY — and confine it to radio items. "Emergency" ads will receive first attention. Address it to:

SPRAGUE PRODUCTS CO., Dept. RN38
North Adams, Mass.



Ask for Sprague Atoms (midge drys) by name! Use them universally on EVERY electrolytic condenser replacement job!

TUBES WANTED—Will pay list price for new 50L6, 35Z5, 35L6, 12SA7 and numerous others. Have an oversupply of various other tubes for sale or exchange. Send 3c stamp for list. Dolan Radio Service, 187 Union St., Randolph, Mass.

RIDER'S MANUALS WANTED — Vols. 9, 10, and 11. Will pay cash. Also want an 0-1 Ma-meter in good condition. Jim's Radio Shop, Mankato, Kans.

WILL SWAP OR SELL—Seeburgh automatic record changer, 12 record cap., good cond. with pick-up pro. model, commercial type multiple selection, $35; also Readrite analyzer model No. 710-A, will take octal tubes, minus 0-10 ac voltmeter, measures dc v. & ma., 2 mtrs. inc., working cond., can be used as multi-mtr., sold new for $35, only $10. Askin Radio Service, 1107 S. Main St., Paris, Ill.

WANTED—A 32 v. D.C. to 110 v. A.C. converter or vibrapack, 75-150 watt, in good condition. Henry Bouw, Pepacton, N. Y.

FOR SALE—134 issues of SERVICE (radio magazine) from March 1932 to May, 1942, for $25. All in good condition. A. Abrahamsen, 2633 Johnson St., N. E., Minneapolis, Minn.

WANTED—30 juke box or phono amplifiers, new or used; 2A3 or 6L6 outputs; also Racon or University trumpets, units and horns. Cash. Engineering Associates, 410 Marian Avenue, Lima, Ohio.

FOR SALE—Rola G12—2500 field, 18-watts, $4; 2 aluminum bells and enclosure for 10 in. speaker, $3.50 each; 40 Meissner IF transformer 465KC, $10; one Atlas WX8 reflexed enclosure (like new) $10. Francis Higgins, 14965 Bringard, Detroit, Mich.

WANTED—Thordarson 2A3 phono. amplifier, or these Thordarson parts: T-15R05 power transformer, T-90A04 audio trans., T-90S13 output trans., T-15C54 choke, T-74C30 choke, T-67C46 choke, T-18C92 choke, T-14C70 choke. Cash or trade. Send for list. John Repa, Jr., Richlandtown, Pa.

FOR SALE—Supreme model 385 in A-1 condition; also Radio City CO tube checker model 303A, complete with test leads and instructions. Walter Grigaites, R-2, Granville, Ill.

WILL BUY FOR CASH—A V.O.M. of reputable make in excellent condition. Would prefer Hickok or Precision, 25,000 ohms per volt. Do not want a V. T.V.M. Write giving model number, full details of ranges, and price. Cook's Radio Lab., 1110 Prince St., Brunswick, Ga.

FOR SALE—Supreme tube tester type 145, used only a short time, in A-1 condition, in original carton, with instruction sheet. Refer to Rider's Manuals for hook-up and description. Will ship by C.O.D. mail or express for $25—$5 deposit, bal. $20 on delivery. Truitt Radio Service, Novinger, Mo.

IN THE MARKET—For Ohmmeter, signal generator and tube checker. What have you? Send description and price. A. Fischer, 1529 White Plains Road, New York 60, N. Y.

WANTED AT ONCE—Tube-tester, oscillator and analyzer, or V.O.M., for testing latest sets. Give full description and price. Thompson Radio Service, 1700 River Rd., Port Blanchard, Pittston, Pa.

RECORDER WANTED—Professional or semi-professional portable model. Would accept quality radio-recorder combination. What have you? Wm. V. Drinkard, General Delivery, Manette Sta., Bremerton, Wash.

COMMUNICATION RECEIVER WANTED—Such as HQ-120-X in good condition with speaker. Give full details and price. Sgt. Alex O'Kulich, Co. A 2nd Arm'd Sig. Bn., East Garrison, Fort Ord, Calif.

FOR SALE—Two type B5 Bliley Xtals, new sealed holders, frequencies 7212 and 7224, never used. WANT National One Ten receiver, R.M.E. Dm30XA or DM36A Browning converter; Abbott TR 4 MRT 3 or a S 29 Sky Traveller. V. Howerdel, 102 Hancock Ave., Jersey City, N. J.

WANTED—Volt-ohm-mil. meter; signal generator, also Rider's Manuals. State price in first letter and give full description. Wm. J. Schwallier, 514 Ninth St., Henderson, Ky.

FOR SALE—35-watt amplifier, 12-in. P.M. speakers and carrying case; Racon giant units. National Sound Equipment Co., 625 Main St., Worcester, Mass.

WILL PAY CASH—For Hickok 155 Traceometer or Rider chanalyst; also want appliance tester such as Hickok model 900. Must be in A-1 condition. Clyde Smith, Samson Radio Shop, Samson, Ala.

FOR QUICK CASH SALE — Complete radio servicing laboratory, as follows: Complete set of Rider's Manuals, Vols. 1 to 11; up-to-date Supreme instruments, oscilloscope, analyzer, signal generator and frequency modulator, audolyzer, tube and set tester; Triplett signal generator and multitester; Crosley manuals; Mallory-Yaxley Encyclopedias; eight-drawer metal parts cabinet; strong chassis cradle; workbench; 275 resistors; 40 jars filled with nuts, screws, washers, lugs; 30 condensers; complete set high-speed drills; drill gauge, wire gauge, screw gauge; dozens of drills, taps, dies, etc.; 100 vacuum tubes, all good; hundreds of small parts too numerous to mention; Philco manual; tube manuals; 250 radio magazines. Leaving for service. Will close out for $400 for immediate cash sale. Edwin A. Seeburg, 143 Washington St., Long Branch, N. J.

WANTED—British Admiralty Handbook of Wireless Telegraphy, Vols. I and II, in good condition. Will pay cash. G. A. Soderlund, Box No. 40, Sturgis, Sask., Canada.

FOR SALE—Readrite No. 710-A set tester, three meters — D.C. voltmeter, A.C. voltmeter, D.C. milliamperes—price $20. Set includes accessories and instruction sheet, and has been used only 3 times. Jacob Husak, Center Moriches, N. Y

WANTED—B.R. 151 Jensen speaker cabinet (for 15-in. speaker) new or used. Give full particulars and price. Robert E. Woolf, 406 E. University, Gainesville, Fla.

FOR SALE—Stancor model 125 6-volt power pack; Janette CH25, 75 watt, 115DC-110AC converter; Green Flyer automatic, 2 speed record player; 8-in. Jensen peri-dynamic speaker and case; tubes; resistors; and condensers. Kenneth Stoll, 512 5th Ave., Asbury Park, N. J.

FOR SALE OR SWAP—Hickok AC49 tube tester mutual conductance type up to 30 volt; adaptors for some metal tubes, $15; P.P. parallel 50's amplifier Western Electric parts, $30; Peerless speaker, $2; 2 MF paper condensers 200 v. 15c; woodlathe, $12. Want gas generator. Al. R. Dayes, 1418 81st St., Brooklyn, N. Y.

FOR SALE—One GE No. AZ-133A phonograph motor complete with turntable; one Motorola 8-tube push button auto radio No. 969; one Jewel pattern No. 54 0-3 DC ammeter; one Jewel pattern No. 54 0-7 and 0-140 combination DC voltmeter. Write for prices and details. Louis E. Farrell, 316 Pine St., Burlington, Vt.

THEIR LITTLE ADS BROUGHT BIG RESULTS!

A Few Typical Comments From Among Hundreds We Have Received

"I have had excellent requests from my Trading Post ad—seven requests in three days, and they're still coming." W. T. N., Illinois.

"Thank you for my advertisement in the Sprague Trading Post. Received 4 replies to my request for an oscilloscope." G. B., Brooklyn.

"I made a trade on a Rider Manual for the micrometer. Thank you again." C. D. L., New Jersey.

"Thanks for running my ad—I sold two meters right off the bat." A. R. D., New York.

"I received an answer to my ad two days after the magazine came out, and a week later I had the oscillator I wanted." F. L., Conn.

"Received several replies and purchased the condenser tester I needed. I gave the other replies to other servicemen who also needed such equipment." J. A. S., New York.

"Please accept my sincere thanks. I was literally swamped with replies to my Sprague Trading Post ad and had no difficulty in disposing of the apparatus at a good price. This is a splendid service you are rendering—and just one more reason why we servicemen will continue to buy Sprague Condensers." R. B., New York.

Send in Your Ad *TODAY!*

SPRAGUE PRODUCTS CO.
North Adams, Mass.

SPRAGUE CONDENSERS
AND KOOLOHM RESISTORS

Obviously, Sprague cannot assume any responsibility, or guarantee goods, services, etc. which might be exchanged through the above advertisements.

Porter possesses a keen knowledge of radio communications and equipment that is being used so successfully by our troops. He is well known in Washington and contributed greatly in the preparation of the November, 1942 Special U. S. Army Signal Corps issue of RADIO NEWS. Our readers will be given exclusive material and photos direct from our various fighting fronts. American manufacturers of radio equipment will welcome this addition to our staff as Mr. Porter will be able to get first hand information as to the performance of their units in combat. We know that our readers join us in wishing Mr. Porter bon voyage and a happy return.

MAJOR GENERAL DAWSON OLMSTEAD, formerly Chief Signal Officer of the United States Army, retired on June 30 to take over his new position as Military Representative on the Telecommunication Board. The new Chief Signal Officer is Major General Harry E. Ingles of Lincoln, Nebraska, formerly Deputy Commander of American troops in the European theater under the late Lt. General Frank M. Andrews. The editors of RADIO NEWS are proud to have been able to present the story on the part that the SCR-299 (developed as a result of Gen. Olmstead's original idea for a fast-moving mobile radio unit) has played in maintaining our communications on our many fighting fronts, particularly during the recent African campaign. This story was based on a recent interview with General Olmstead whom we have had the pleasure of knowing personally for many months. We know that our readers join with us in extending our congratulations to General Olmstead, and to General Ingles, our new Chief Signal Officer. 73 . . . OR

Scientific Farming

(Continued from page 31)

These experiments have advanced sufficiently to give validity to the idea that improvement of strains of fruits and vegetables is possible through the use of electrons.

Soil scientists of the U.S. Dept. of Agriculture have determined by pioneering experiments that radio waves have great value in adding extra fertility to some soils. The Westinghouse Electric & Manufacturing Company has designed an electronic eye for measuring the radiation of the sun in different sections of the country. These radionic devices resemble an oversized radio tube. At its upper end is a flat metal button about the size of a fifty-cent piece, surrounded by a circular wire electrode. As a sun meter, the metal button in its refined state is sensitive only to that portion of the ultraviolet light in sunlight which produces sunburn. Sun rays, hitting the surface of the disc, cause the metal to release a stream of photo electrons which pass to the electrode. So small is the current passed that it must be expressed in micro-watts. These electrons, by means of proper circuits, cause a small condenser to charge up. After a period of several seconds the condenser discharges, actuating a sensitive relay trigger. These discharges can be very accurately counted by means of a recording device and are then used by the scientist and the agricultural colleges in making crop studies and surveys for the benefit of the farmer.

Perhaps one of the most startling accomplishments credited to radionics, which will result in greatly increased production, is the discovery of the exact nature of the tobacco mosaic virus. By means of the radionic microscope scientists have been able to see, for the first time, this virus of the plant disease which for many years has cost tobacco growers untold millions of dollars. While it is too early to announce any definite results from this discovery in the way of a cure, the future holds promise of complete success. This microscope will be used more and more in the discovery and cure of other plant diseases.

Pasteurization is the process of exposing liquids to a temperature of 131 to 158 degrees Fahrenheit for a definite period of time in order to kill all bacteria which cause fermentation. However, this process, in the light of present day knowledge, leaves much to be desired since this high temperature destroys some of the vitamins present. A new process of sterilization without the use of heat or chemicals has been announced by the inventor, Herbert S. Ogden, of Los Angeles, California. This process uses electron streams to accomplish the desired result. The use of this process does not exercise a contaminating influence by the presence of ozone or other chemical odors. It affords an agent having uniform action, literally bombarding the milk or other fluid with millions of electrons. The flow of liquid through the system is at a predetermined rate, this being determined by the density of the fluid, the intensity of the sterilizing agent, and the minimum number of bacteria to be tolerated. More simply, the process consists of forming a film of milk or other liquid on a moving surface and then directing a stream of ultra violet rays through this film for a specified length of time. The time element is governed by such factors as the number of bacteria to be destroyed, the intensity of the electronic ray and the density of the liquid.

The apparatus has a supporting frame which somewhat resembles an automobile motor hood. Contained within the supporting framework is a gas-tight, enclosed hood, sealed against a section of the main support by sealing material and a wing nut. Resting on this section, or member, is a ball-bearing, which is a journaled shaft of a closed cylinder.

A portable outfit could be made for dehydrating soybean, fodder, alfalfa, clover, and grass. More nutritious hay, with greater carotene and vitamin content is promised by such a machine,

which separates the leafy portions from the woody stem and crushes the sappy parts, the electric eye being the expert grader. This dehydrator would combine several functions into one operation. It would feed green fodder or other material intended for livestock onto an endless belt, cut the plants into suitable lengths, separate, electronically, the leafy portions from the sappy stems, crush the stalks, pick up the layer of drying material, turn it upside down and deposit it loosely along the traveling conveyor. Soybeans, alfalfa or clover are loaded onto this slowly moving conveyer belt. After passing through crushing rollers which pulverize the sappy stems to a more rapidly drying status, they are then carried through a heating chamber where moisture is expelled. During the process of drying, the temperature is adjusted correctly, thus avoiding scorching or burning the material, a common complaint with some driers. There are a succession of heat zones each supplied with low humidity air, heated to exactly the right temperature, to attain the maximum evaporative effect for each stage of the dehydrating process. The drying is conducted, in part, in an oxygen-free atmosphere and in a chamber wherein all products of combustion are burned completely without smoke.

The units of this community dehydrator consist of a supporting framework; a continuous belt of two flexible steel bands mounted on the framework; a main boxlike structure, extending the length of the conveyer belt and forming an airtight housing for the conveyer screen; another chamber which has a metallic tube and an oil burner for heating the material to be dehydrated; electronic tubes; and other equipment. The interior of the drying chamber has eight cross openings with an air intake opening controlled by a door. This series of hot-air discharge chambers provides an accurate control over the amount of hot gas admitted to chambers.

The above mentioned examples of various applications of radionics to modern farming, serve to show to a certain extent what progress has been made and something of what may be expected in the future. No article of this nature would be complete without mentioning the future possibilities of maintenance and repair in this field. The many radionic devices, which are now available, and those which will be available in the future, will require the services of a great many trained technicians. Men presently engaged in radio servicing, or kindred maintenance, will find this a profitable and timely field to enter. The servicing of the devices should do much to build a splendid post war business for these men, particularly in rural areas.

It is important that the serviceman bring his knowledge up to date on these new devices in order that he can take full advantage of these new opportunities.

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Saga of Vacuum Tube
(Continued from page 27)

the tube, and hence might not be considered to be within tne scope of the de Forest patents. On December 31, 1918, U.S. Patent No. 1,289,981 was issued to Weagant on a tube of this type.[117] (See Figure 30.) The Weagant Valve, as the device was called, was never applied commercially to any great extent, probably because the decision in the Marconi-de Forest suit was favorable to the Marconi Company. Figures 31, 32, and 33 show various forms of the Weagant Valve, that of Figure 33 being a proposed commercial form of the device. The circuits to be used with this valve were similar to those used with the conventional three-electrode tube, and were published in a magazine article about the time the patent was issued.[118]

With the development of the multi-electrode tubes of the late 1920s and early 1930s communications engineers had available a method of obtaining substantial amplifications at radio frequencies. This resulted in a second revival of the diode for use as a detector. When the signal input to the detector can be made of the proper value, this type of detection presents certain advantages in the way of freedom from distortion. Hence many modern radio receivers use such detectors. A typical detector tube of this sort is the RCA 6H6, which is a double diode detector. Study of Figure 34 will clearly show the changes which differentiate this modern diode from its progenitor, the Fleming valve. These advances are in the nature of engineering refinements, the principle of operation is still the same. The output, however, is utilized not only

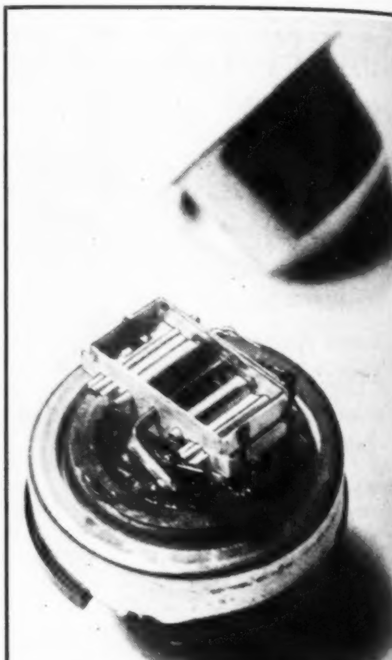

Figure 34.


"IT'S A SWELL PLACE FOR MY ECHOPHONE EC-1 AND BESIDES, SHE LIKES TO GET POLICE CALLS"
PVT KILDAY

to provide the audio waveform which was superimposed on the carrier at the transmitter, but also to provide energy for other purposes, such as automatic adjustment of the gain of the preceding radio frequency amplifier. This provides an audio frequency output which is reasonably constant and independent of the variations in the received signal over the operating range of the circuit.

There is still another use of the diode on which we have not yet touched. This is in the field of power frequency rectification. In the early wireless receivers, even well into the broadcast era, dry cells or small storage batteries were used as a source of plate potential. Their use had its disadvantages. The cost was high for the energy which they furnished. The plate potential always existed, even though the set was not in operation, and might be dangerous. If heavy duty batteries were used, in an attempt to reduce the cost per energy unit, the space required for them might be as great as for all the rest of the receiving equipment. These disadvantages became more important with the trend to the higher voltages required for the power output tubes needed for satisfactory loud-speaker operation.

In the case of tube transmitters, the plate potential was at first supplied by generators. High voltage d.c. generators are difficult and expensive to build and, like all rotating machinery, require expert maintenance. A static source of power for the transmitting tubes was much to be preferred, hence the power rectifier was developed.

The first power frequency rectifier of the thermionic type was due to Dr. Arthur Wehnelt of the University of Erlangen, the inventor of the Wehnelt, or oxide-coated, cathode.

In 1903 Wehnelt published a paper describing a method of obtaining "negative ions" in great quantities from incandescent metallic compounds. He used a platinum wire, or platinum strip, coated with calcium or barium oxide, as the cathode in a discharge tube and found that there was a strong emission of negative ions from the cathode when it was made incandescent. He further described experiments which he made on these phenomena in other papers in 1903[120] and 1904.[121]

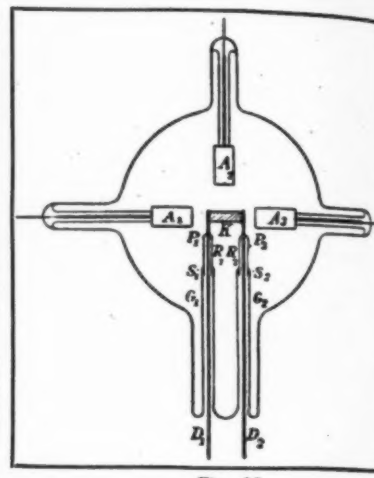

Fig. 35.

On January 15, 1904, he applied for a German patent[122] for the use of such a discharge tube, containing a heated cathode with these metallic oxides, as a rectifier for transforming single phase and polyphase alternating currents into direct currents. No mention was made of any application to high frequency oscillations or wireless telegraph use.

In 1905 he described the use of this device in an article[123] entitled "An Electric Valve Tube" and suggested its use for charging storage batteries, and for supplying potential for the direct operation of Roentgen tubes. This paper was a short summary and was followed by a more complete exposition in 1906.[124] In this last paper he showed that this valve-tube could also be used as a rectifier of high frequency currents. However, it should be noted that this was subsequent to the papers published by Fleming on the use of his valve as a rectifier of high frequency oscillations, and in fact Wehnelt refers to Fleming's work in a footnote in his article. The tube as constructed by Wehnelt is shown in Figure 35.

There appears to have been little

done in this phase of diode development for a number of years thereafter, until the necessity arose for obtaining very high direct current potentials for x-ray work. The initiative in the subsequent development work along this line appears to have been taken by the General Electric Company, whose work will be described in a subsequent article.

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124. *Wehnelt, Arthur: "Ein Electrische Ventilrohr." Annalen der Physik, Vol.* 19, 1906, *pp.* 138-156.

Figure Captions

Figure 28. Fleming's Later United States Patent, showing use of biasing potential on plate.

Figure 29. Left and Center, Electrad Diode. Right—Margo Detector.

Figure 30. Weagant Valve Patent.

Figure 31. Left—Weagant Valve with outside electrostatic control element in position. Right—Weagant Valve with control element removed. Photograph Courtesy *Radio Corporation of America.*

Figure 32. Group of experimental Weagant Valves.

Figure 33. Proposed Commercial Form of Weagant Valve.

Figure 34. Modern Diode. RCA 6H6 with cover removed. Photograph Courtesy *Radio Corporation of America.*

Figure 35. Wehnelt Rectifier for Three Phase Operation. Reproduced from *Annalen der Physik—1906.*

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Delay & Timing Circuits

(Continued from page 34)

inductance L. The effect of this charge is to bias the Thyratron grid more negatively and eventually to cut off the flow of anode current. When cut-off occurs, current ceases to pass through the controlled device, and the capacitor discharges slowly through the inductor. The cycle then is repeated at a rate determined by the L and C values.

SYSTEM 8. Direct Thyratron control of devices at a very slow rate is another interesting application of the two-stage circuit consisting of vacuum-tube timer-Thyratron controller. Such an application is the slow dimming, or brightening of lights in response to the depressing of a switch.

In this system, the R and C values in the vacuum-tube timing stage are selected to permit a long control interval and the circuit is arranged to enable either a gradual building up of voltage across a plate load resistor (as in Figure 9), a gradual decay of this voltage, or either of the two which may be selected at will. The lamps, or other devices to be slowly controlled, are connected directly in the anode circuit of the Thyratron tube. (See Figure 9). If a single gaseous tube does not pass sufficient anode current to operate the controlled device, several of these tubes may be connected in parallel for the purpose. Anode voltage is obtained directly from the secondary winding of the transformer T, and half-wave rectified current supplied to the controlled devices in the anode circuit.

Timing Circuits

It is obvious that several of the circuits already described might be used for timing purposes; i. e., they might be adapted to signal the beginning and end of a certain time interval, instead of for delayed control purposes. Likewise, they might be employed to govern automatically the length of various processes to be timed.

Numerous present applications exist for electronic timing devices. Some of these are the timing of chemical operations and other general laboratory operations; the timing of camera exposures and photo finishing processes; timing of electric welders; generation of time impulses for various scientific instruments, life test operations, etc.

Aside from the circuits already described, which may be adapted to these uses, certain other arrangements have been developed expressly for timing. A few of these will be explained in the following paragraphs.

SYSTEM 1. The simplest electronic timing circuit is shown in Figure 12. This circuit is a type of gaseous tube relaxation oscillator of the most rudimentary variety, nevertheless it is very reliable in operation and is equally inexpensive and compact.

Operation of the circuit is explained

as follows: Capacitor C is charged by the 100-volt d. c. source. This capacitor charges at a rate determined by its capacitance and the resistance R. When the voltage across the capacitor due to the charging current, reaches the ignition potential of the neon lamp, the latter is fired and the capacitor voltage is thereby reduced sharply until the extinction potential of the lamp is reached, whereupon the neon discharge is extinguished. The circuit is then ready for a repetition of the cycle.

By properly proportioning the values of C and R, the alternate charging and discharging of the capacitor may be set at any desired rate, the relay opening and closing at the same rate. In laying out the circuit, the reader must be careful that the R value be kept such that the sum of the resistance already enclosed in the base of the lamp and the reactance of the relay be half (or less) of the timing resistance.

This circuit may be used to control repetitious operations directly, through the relay, or to signal the start and stop of a given time interval. If the experimenter desires, the relay may be dispensed with entirely, being replaced by a suitable resistance. The drop developed across this resistor by the capacitor discharge current may then be utilized directly to trigger a gaseous triode or tetrode which in turn may control a piece of machinery, recorded, or signal alarm directly in its anode (plate) circuit.

This timing circuit, being by nature an oscillator, may be adjusted to respond at any convenient rate between 1 cycle in several hours to several thousand cycles per second!

SYSTEM 2. A timing system, entirely a. c. operated although including only one tube, is in wide use among amateur photo finishers. This circuit which turns the printing or enlarging lamp on and off, exposing for a predetermined time interval, is shown in Figure 13.

Rt and Ct are the timing circuit elements. The d. c. relay and tube cathode resistor Rk are connected in series in the cathode circuit. Cf is an anti-chatter capacitor for smoothing the r. a. c. cathode current through the relay coil. AC plate and tube heater voltage are obtained directly from the windings of transformer T.

In operation, switch S is thrown to the No. 2 position. The relay picks up at that instant, switching on the lamp. At a later instant determined by the magnitudes of Rt and Ct, the relay drops out, switching off the lamp. S rests in the No. 1 position.

The grid bias voltage, with S in position 1, is the drop produced across the series circuit containing the relay and Rk. This bias drops at the instant S is thrown to position 2, being then equal to the cathode circuit drop less the drop across Rt. The resultant low value permits the plate current to rise to a value high enough to pick up the relay and switch on the lamp.

The voltage drop across Rt decreases as Ct continues to charge, the negative bias thereby increasing until the decaying plate current drops out the relay and switches off the lamp.

* * *

Various timing circuits, either of the simple vacuum-tube type or the more complex arrangements employing gaseous triodes or tetrodes, may be employed to control rapidly the *on-time* and *off-time* of electric welders. Resistance and spot welders may thus be arranged to operate during any length of time during a single a. c. cycle or up to an interval several cycles in length. This action is accomplished chiefly by exciting the control and regulator tubes with alternating voltage so that the conducting time of the heavy-current gaseous control tubes may be regulated over portions of the excitation cycle.

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Variable Inductors
(*Continued from page 44*)

switch blade and closely-spaced switch contact points. Tapped coils are successfully employed in transmitters in which the inductance tapping is not carried over too wide a range, provided the current is switched off while the coil switch is rotated.

Variometer

The variometer consists of two coils placed in inductive relation with each other. One coil is stationary, while the other is made variable, rotating within the stationary member. In one position; the field of one coil cancels the other, reducing the resultant inductance, while in the other extreme position, the two fields aid each other. Between these limits, various degrees of interaction are obtained, yielding various values of inductance.

The variometer is illustrated in Figure 4. The rotating coil is mounted within the stationary coil; while in another arrangement, the variable slides in and out of the fixed coil. In either arrangement, the two coils may be connected either in series or in parallel with each other. The standard symbol for the variometer is shown in Figure 5.

The variometer is continuously variable and is smooth in action. Although it offers a slightly more difficult constructional problem, its obvious advantages recommend it to many critical uses. Laboratory standards of inductance are almost always variometers when the variable feature is a requirement. Variometers may readily be ganged for single dial control and may be tracked by adjusting the angle of rotation for individual rotating coils.

Tre variometer chosen for the writers measurements is shown in Fig. 4. It is a small unit, consisting of a stationary coil wound on a bakelite tube, and rotating coil wound on a concentric

wooden spool, varnish treated. The coils were arranged for connection either in series or parallel for the tests. The following data were taken: Minimum Inductance (Coils in Series) 0.02 mh. Q 46. Maximum Inductance 0.05 mh. Q 47. Minimum Inductance (Coils in Parallel) 0.0042 mh. Q 67. Maximum Inductance 0.012 mh. Q 70.

Variometers manufactured for laboratory use offer inductance variation as great as 8 to 1 for the series coil connection and as great as 10 to 1 for the parallel connection.

Powdered-Iron Cores

Introduction of a powdered core into the center of a coil increases its inductance and Q by an amount depending upon the position of the core. This type of inductance variation has been in use for some time in the tuning of receiver r.f. and i.f. stages. When the iron core is arranged mechanically so as to be moved in and out of the coil, as by means of a cam and tuning dial, smooth variation of inductance may be obtained, and a band of frequencies may be covered. In fixed-tune circuits, such as i.f. transformers, the powdered-iron core may be arranged to be screwed in and out of the coil.

The writer selected for test a commercially-built lattice-wound coil with Polyiron type core. The coil, shown in Fig. 6 (left), is wound on a thin-walled bakelite sleeve. The core is snug fitting and adapted for movement by means of screw adjustment.

The following measurements were made with the coil described above in a standard commercial Q-Meter: Maximum Inductance (core in) 72.40 µh. Q 240. Minimum Inductance (core out) 27.78 µh. Q 139. This represents an inductance variation of better than 2.5 to 1 for the small-size coil tested. A wider variation might be obtained by winding a long coil and providing a long core.

Powdered-iron cores have found greatest utility in trimming resonant circuits over a small frequency range. Examples of this application are in i.f. transformers, pushbutton-tuned r.f. circuits, and other positions in which a fixed condenser sets the circuit to an approximate frequency, exact trimming being left to the core. Powdered-iron-core tuning is not recommended for circuits in which large amounts of r.f. current flows during normal operation.

Metal-Slug Tuning

If a non-ferrous metal plunger or slug is substituted for the powdered-iron core, the coil inductance may be varied in the reverse manner. That is; when the plunger is entirely within the coil, the latter's inductance will be less than before. This type of tuning may be arranged mechanically in the same manner as core-tuned systems.

Action of the plunger-tuned coil is based upon losses within the plunger, which effectively reduce the inductance of the coil. This method is attendant with large losses, however, and is not widely used for that reason.

although it has been employed for trimming purposes in some receiver circuits from time to time.

In spite of its relative inefficiency, the plunger-tuned coil may readily be applied in emergencies when variable condensers are not available for trimming circuits or for tuning over narrow frequency bands. Because of its high eddy current losses, however, this type of inductance variation is not recommended in circuits, such as in transmitters, where large values of r.f. current normally flow through the coil.

Disc-Tuned Coils

Inductance variation over a limited range may be secured by means of a small non-ferrous metallic disc arranged, as shown in Figure 6 (right), to be moved in and out of a coil. Action is very similar to inductance variation by means of a metallic plunger, just described.

The tuning disc is generally constructed of brass or copper and is cut to a diameter slightly less than the inside diameter of the coil form. It may be arranged to travel along a long screw mounted to the end of the coil form, or may be inserted into the form by means of an arm controlled by a dial mechanism.

As the disc moves toward the center of the winding length, the inductance of the coil decreases, reaching its lowest value when the disc is at the exact center of the winding. From then on, the disc is again moving out of the coil, although continuing to move in the same direction, and the inductance increases, reaching the original maximum when the disc is entirely free of the other end of the winding. The maximum inductance range thus is obtained between the center of the winding length and one end of the coil.

Shield-Tuned Coil

Applying the principle of eddy current loss to inductance variation by means of external non-ferrous metallic members arranged within the coil field, we may obtain an "external version" of the plunger—and disc-type tuner systems. This arrangement, illustrated in Figure 7, utilizes a shield sleeve which is moved over the coil to vary its inductance over a narrow range.

Ring-Tuned Coil

Another type of losser tuning widely employed in trimming receiver circuits at high frequencies, makes use of a short-circuited ring. This is shown in Figure 8.

A non-ferrous metallic ring, somewhat smaller in diameter than the coil, is arranged to rotate within the coil. The inductance variation obtained with this type of tuning is very slight, suitable for narrow-range circuit trimming at relatively low frequencies. Q reduction is considerable, being comparable to that occasioned by introduction of metal plungers, discs, or shields within the coil field.

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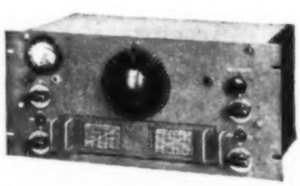

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Book Review
(Continued from page 40)

presented in clear and concise manner and are so arranged that they serve as a convenient and instant reference. It is a valuable adjunct to classroom study and library work for the student and instructor. It saves considerable time and is ideally suited to the radio amateur, technician and engineer both in the library and in the field of operations.

"HENLEY'S TWENTIETH CENTURY BOOK OF FORMULAS, PROCESSES AND TRADE SECRETS," by Prof. T. O'Conor Sloane, A.B., A.M., E.M., Ph.D. Published by *The Norman W. Henley Publishing Company,* 17-19 West 45th Street, New York City. 861 pp. plus index. Price $4.00.

The publishers have prepared this new edition in response to a demand for this type of book which includes many new formulas and deletes those that have become out of date. The new edition contains a glossary of chemical terms and their corresponding names and several pages of useful information concerning the materials required in compounding formulas. The Editors have endeavored to meet the requirements of the home and workshop, the mechanic, the manufacturer, the artisan and the general home worker. Many formulae are included which apply to the product of various types of communications equipment. These include formulas on paints, lacquers, varnishes, etc. Furthermore, it covers completely formulas used for chromium plating and others used in the radio industry.

"RADIO NETWORKS AND THE FEDERAL GOVERNMENT," by Thomas Porter Robinson. Published by the *Columbia University Press.* 278 pp. Price $3.50.

This book covers a comprehensive history of network broadcasting and of its relationships to the Federal Government. The subject, which is of self-evident importance to everyone in any way connected with the radio industry, also concerns every citizen both as voter and as listener. This book presents an engrossing panorama of the development of the industry and its amazing ramifications from the beginnings of wireless telegraphy, through the day, less than a quarter of a century ago, when station KDKA inaugurated regular broadcasting (from a studio in a small garage), down to the present era of national networks. While not a technical book, it serves its purpose well by bringing to executives and engineers a knowledge of the backbone of broadcasting as we have it today.

"PRINCIPLES AND PRACTICE OF RADIO SERVICING," by H. J. Hicks, M.S. Second Edition. Published by *McGraw-Hill Book Company, Inc.,* New York and London. 380 pp. plus index.

This new book is a compilation of basic servicing methods whereby the radio servicemen may become familiar in general fashion with the hundreds of various models of radio receivers now on the market. It is very clearly written and profusely illustrated.

One chapter deals with the servicing of radio receivers and gives the student very complete instructions as to the proper use of tools in the service shop. Of particular interest to the radio serviceman is the chapter devoted to the business side of radio servicing. It shows the pitfalls when improper methods are used in conducting one's business and suggests many ways in which the serviceman's revenue may be increased. This book will make an excellent addition to any serviceman's library.

"ELEMENTS OF RADIO," by Charles I. Hellman. Published by *D. Van Nostrand Company, Inc.,* 250 Fourth Avenue, New York City. 307 pp. Price $2.00.

This book was written to meet the requirements of the pre-induction training course in fundamentals of radio as set forth in the *War Department* outline, PIT 201. It is designed to serve as a full year course in the first study of radio principles and it assumes that the student has had no previous knowledge of radio. Quantitative aspects of radio are given careful treatment. Each new formula is explained and implemented by one or more worked-out examples which are immediately followed by problems to be solved by the student. At the end

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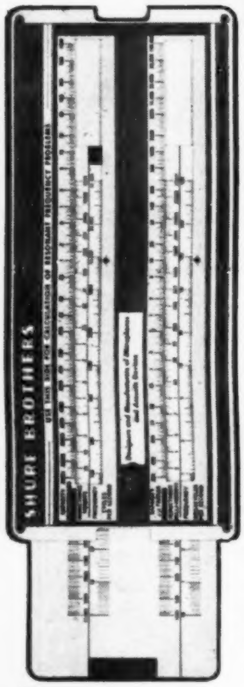


of each chapter there are numerous review exercises, both questions and problems. Demonstrations described in the text may be performed with parts from a discarded radio receiver and the equipment available in the science room. The understanding of alternating current phenomena has been simplified by weaving the essential mathematics into the discussion at the time when it proves most useful—during the study of alternating currents.

This book has been treated from a practical viewpoint, in that it urges pupils to undertake the dismantling of discarded receivers. The author is to be commended for his treatment.

Spot Radio News

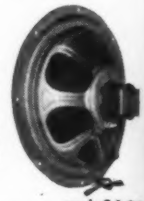
(*Continued from page* 14)

And his British patent is even more startling, for his drawings show a *horseless carriage* with a radio set that he termed a *raidio.* Unfortunately, Mr. Stubblefield refused all offers to develop his system, and in 1928 he died unknown and practically destitute.

DURING THE EARLY PART OF FEBRUARY when the terms *victory model, utility model* and *simplified model* were running wild in Washington, a standard terminology, *war model,* was adopted. This term was to have been used to describe commodities which met the requirements of specifications in production and price regulations issued by government war agencies. However, during the ensuing months the hopes of possible production of war models seemed to diminish and the term *victory parts* or *standardized parts* returned once again. There is now talk of the return of a new type of model known as *postwar model.* This time Washington promises that the term will really be used. Well, we'll see.

THE STRICT AND SEVERE L265 has been amended in a manner favorable to the industry. No longer, for instance, is it necessary to have special WPB authorization to remove the radio from an automobile or to sell that removed radio. The recent amendment also provides for the removal of the restriction covering sale of automobile radios and automatic phonographs to the consumer, provided, of course, that such equipment was completed on or before April 24th of this year. An additional concession made by the amendment is permission to sell antenna, antenna couplers, power supplies and battery cables for battery type home radios, automobile radio control assemblies, loud speakers and cables. Heretofore, all this equipment was not available for sale or transfer.

IT'S A CASE OF BAD DISTRIBUTION IN LONDON, TOO. A recent survey shows that a shortage of electrolytic condensers and tubes has been



caused by maldistribution. For some reason or other quantities of this merchandise were being directed to unauthorized sources. The Board of Trade is making every effort to correct this evil. American methods of control are being studied.

RADIO BECAME A TRUE MESSENGER of mercy when it served as a vital beacon to a group of damaged Allied planes during the crucial and final phases of the campaign in North Africa. A portable radio station located on a mountain range in Tunisia directed many pilots during this historical period. Eight men who operated the station were isolated at the mountainous retreat for weeks. However, they stayed at their posts and saw to it that these vital messages were transmitted and received by the Allied planes.

FREQUENCY MODULATION which has been gaining many friends in England, was recently the subject of a very interesting analysis by Dr. K. R. Sturley of London. In a fifty-eight page presentation he presents a most thorough analysis on the subject. While many of the pages are devoted to an engineering treatment, there are many appropriate chapters that the laymen can understand. Dr. Sturley discusses many of the perplexing peculiarities of the general nature of the system in a most lucid way.

Although the book has been published in London and distributed there, your correspondent has been told that it may be available soon in America. We hope so.

THE FEDERAL MANUFACTURING AND ENGINEERING CORPORATION has been notified by Under-secretary of War Robert P. Patterson, that they have been awarded for the second time the Army-Navy Production award for meritorious service on the production front. This second award is symbolized by the white star which now takes its place on the "E" flag which was received six months ago.

The Federal facilities now comprise three plants with more than 500 employees. The Federal Manufacturing and Engineering Corporation has been in business 21 years, and for the past 15 years have been suppliers for the War Department of radio communications equipment. David H. Engelson, President, Jesse C. Fishel, Treasurer, have both been with the company since its inception. M. Kaplowitz, Chief Engineer, has been connected with the organization for 15 years, making a total of 57 years of constant activity for these three executives.

PERSONALS . . .

When Commander **PIERRE BOUCHERON,** USNR, met one of the members of the radio industry, also in the Navy, during actual duty, the Commander had difficulty in identifying himself. Seems as if the Commander had so heavy a growth of

whiskers, that he was effectively disguised. And when a photograph of the Commander with this beard was shown around the Farnsworth plant, where he was General Sales Manager before the war, it also took several moments before recognition came to the fore. The Commander, who was visiting Farnsworth, is back on Naval Duty again. . . . At the recent RMA Conference in Chicago, **PAUL V. GALVIN** was reelected president. **R. C. COSGROVE** was elected chairman of the Set Division. **M. F. BALCOM** was reelected chairman of the Tube Division and **RAY E. SPARROW** was reelected chairman of the Parts Division. **THOMAS A. WHITE** was elected to the post of Amplifier and Sound Equipment Division chairman. Many Government officials were present at this conference. Among these were, **JAMES L. FLY,** chairman of the FCC; **RAY C. ELLIS,** director WPB Radio and Radar Division; **BRIG. GENERAL JOHN H. GARDNER,** Signal Corps, Wright Field; **REAR ADMIRAL A. M. CHARLTON,** Navy Department, Chicago; **CAPTAIN C. A. RUMBLE,** Navy Department, Washington; **F. D. TELLWRIGHT,** director ANEPA and **FRANK H. McINTOSH,** WPB Radio and Radar Division. . . . **JOHN S. HABER,** vice-president of Philco International, died recently, while on a trip to Cuba. . . . **RAYMOND G. ZENDER** of Lens Wire has been appointed a consultant on the insulated wire and cable section of the WPB Radio and Radar Division. . . . **SERGEANT BARNEY ROSS** recently visited Chicago and dropped in to speak to the workers of Shure Brothers about the importance of microphones on the battlefield. . . . **WILLIAM B. LEWIS,** formerly with the Columbia Broadcasting System, who joined the government services in the early fall of 1941, has left Washington. No future plans have been announced. . . . **WILLIAM S. PALEY,** president of the Columbia Broadcasting System, and **EDMOND A. CHESTER,** director of short wave broadcasting of CBS, were recently awarded the highest civilian decoration of the Cuban government, The Carlos Manuel de Cespedes National Order of Merit, for their achievements in furthering continental solidarity through the creation and operation of the 97 station-chain linking all of the twenty Latin American republics. . . . The noted communications inventor **GEORGE WASHINGTON PIERCE** has been awarded the Franklin Medal of the Franklin Institute in Philadelphia, Pennsylvania. Professor Pierce is known for his famous oscillator circuit, which is used so effectively in many transmitters. Professor Pierce also developed the mercury vapor detector and amplifier, the equivalent to the Thyratron which was developed by General Electric later on. . . . **JOHN K. HILLIARD** who was formerly chief transmission engineer of MGM sound division, and more recently a consultant at the Radiation Laboratories of M.I.T., is now chief engineer of the Radar and Motion Picture Division of Altec-Lansing Corporation of Los Angeles, California.

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Air Raid Alarm Circuits

(*Continued from page 25*)

to be sure that the audio voltage is impressed between the starter anode and cathode of the first tube, since the cathode is above ground and incorrect connections would affect the amount of voltage on the tube. Incidentally, the plate voltage of the last audio tube in the receiver should not be more than 225, since this is the breakdown voltage of the OA4G. Since the tube replaces the cathode resistor of the last stage, a cathode condenser should not be used in this stage.

Using the values of ½ megohm and 1 μfd. in the series-bridging circuit, the tone will be heard after five seconds of tone, and the static interrupting time. These values can be changed to provide any desired operating time delay action.

The receiver used with this system should have a good avc, particularly if a weak signal is to be monitored.

The 50,000-ohm resistors are the current limiting resistors for the two trigger tubes. Starter anode currents should be a maximum of 200 microamperes for both tubes.

A very unique alarm system is in operation in a broadcasting station in Indiana. Developed by Victor H. Voss, chief engineer of WIND, the circuit (Fig. 5) is designed to operate on a warning tone of 20 to 30 seconds duration. And almost any superheterodyne type of receiver can be used with his system. In this system, a signal from the last i-f stage is fed to one diode section of a 6H6, functioning as a second detector. The audio output of the detector is fed to a 6C5, which is used as a voltage amplifier. This amplifier drives another 6C5 filter tube. Then the output of the filter tube is fed into the primary of a transformer. The voltage developed across the transformer secondary is rectified by the other section of the 6H6. The output of the second diode section of the 6H6 is then fed into a relay circuit and travels across a load resistor. This resistor is in series with the grid circuit of the 6C5 relay control tube. The 22.5 v. battery provides sufficient negative voltage to cut off the anode current of the 6C5 relay control tube in the absence of an incoming carrier. The alarm operates if the carrier is cut off. However, in the presence of a carrier, a voltage is developed across the diode detector load. This partially balances out the bias battery, allowing sufficient current to flow in the control tube to close the relay. Thus the alarm circuit then becomes available for the alarm tone. Upon receiving the warning tone, a voltage is developed across the load resistance in the relay circuit of the second 6H6

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Detection and Prevention
(The modern role of electronics as a Scientific Sleuth)

section. This voltage balances out the carrier voltage developed across the detector diode load resistor allowing the bias battery to cut off the plate current of the control tube and consequently opens the relay and produces an alarm. This alarm is a bell, which rings, until the operator throws a switch, which removes it from the circuit and connects a monitor speaker over which announcements may be heard. Depression of a reset button when the alarm period is over, restores the system to its original stand-by condition.

Incidentally this unit is so designed that a warning is provided not only when the required warning tone is received, but also in the event that the monitored station carrier, the unit itself or the associated receiver fails.

The relay used has a d.c. resistance of 5000 ohms. It opens at 6 ma. and closes at 12 ma. If one of lower resistance must be used, a series resistor must be added.

In making the initial adjustments of the receiver, the r.f. gain should be adjusted to give a value of 15 ma. in the plate circuit of the 6C5 control tube.

All of the systems described have gone through an intensive series of tests and have proven themselves extremely reliable. We hope that they will never have to be used for other than tests. But if the critical emergency does arise, they will be ready to serve and serve well.

-30-

Wide Band Amplifier
(Continued from page 22)

that R_LC_f equal C_cR_g. Knowing all these values but C_c we can calculate its capacity.

$$R_LC_f = C_cR_g$$

$$980 \cdot 6.37 = 500{,}000\, C_c$$

$$C_c = \frac{5800}{500{,}000} = .0116\ \mu\text{fd.}$$

The capacity of the coupling condenser should be .0116 μfd.

In practice it is wise to have the reactance of the screen by-pass condenser at the lowest frequency desired equal to one-tenth or less of the value of the screen voltage dropping resistor.

Having made the low frequency compensation, we can now expect that it will faithfully amplify square waves (the criterion in judging the quality of amplifiers) with fundamental frequencies as low as 50 cycles per second.

If the low frequency compensation is not carefully calculated, the amplifier may be either over or under compensated as shown in Fig. 9.

Having been compensated for both high and low frequency loss, the amplifier will now have a nearly uniform response extending from 50 cycles to 5 megacycles. The amplification at the two limits being .707 of the amplification at the intermediate frequencies.

-30-

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This section is designed to help the radio industry obtain trained, experienced, technical men to facilitate vital war production.

Letters to the Editor on the SPECIAL AVIATION COMMUNICATIONS *Issue of RADIO NEWS*

THE June Aviation Communications issue of RADIO NEWS met with wide acceptance—not only from our regular readers—but by the military personnel of our various branches of service. It is most gratifying that we have been able to contribute to the war effort by publishing factual information on the part that radio is playing, both on the fighting, as well as the home fronts. Hundreds of letters have been pouring in—commenting favorably on the June issue. A few of them appear below:

We wish to express our deep appreciation to those who have sent letters and comments on our undertaking.

". . . You have done another commendable piece of work in presenting such a comprehensive résumé of outstanding achievements in the field of Aviation Radio. This is a comparatively little known field which constitutes a very vital part of the vast communications system so essential to the success of our military mission. This edition, as a reference book on the subject, is indeed a direct contribution to the general knowledge of a most important subject."

Dawson Olmstead
Major General
Chief Signal Officer of the Army

". . . I have noted the information contained therein with a great deal of interest and think you are doing a swell job. . . ."

Brehon Somervell
Lieutenant General Commanding
Army Service Forces

". . . It is one of the best I have ever seen up to date.

As one radio man to another, and as one who is tremendously interested in the communication features in aviation, I feel that you have made a tremendous contribution to our war effort and, also, for future aviation. . . ."

Karl Stefan
Congressman, 3rd Dist. Nebraska

". . . This issue is a fine piece of work and gives the authoritative story on the part communications are playing in the tremendous military undertaking now before us. You are to be congratulated on the publishing of a very beautiful and informative piece of work."

W. H. S. Wright
Lt. Colonel, Cavalry
Aide to the Secretary of War

". . . This appears to be a comprehensive picture of this important phase of the war job. I shall circulate it among my associates who are particularly interested in the activities covered."

C. H. Lang
General Electric Co.

". . . It is particularly interesting to those of us who are engaged in helping the production of this equipment and we have found it of great benefit."

E. T. Herbig, Jr.
Capt., Sig. C
Officer in Charge
Army-Navy Electronics
Production Agency

". . . I was really amazed at the completeness of the issue and found its contents highly interesting, particularly those referring to the Technical Training Command's schools.

I sent it around to the chief of staff and all the staff sections in these headquarters and hear much favorable comment. I believe it a worthwhile contribution indeed. . . ."

G. R. Johnston
Lt. Col., AC
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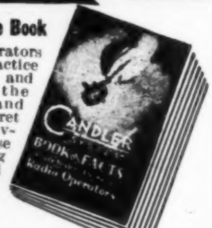

It shows that "crack" operators rely on something besides practice to develop their high speeds and proficiency; it explains the "knack" of sound-sense and sound-consciousness—the secret of speedy sending and receiving. Once you acquire these mental processes, reading code becomes almost second nature to you; just as the swing rhythm of a dance band becomes automatic to musician and dancer.

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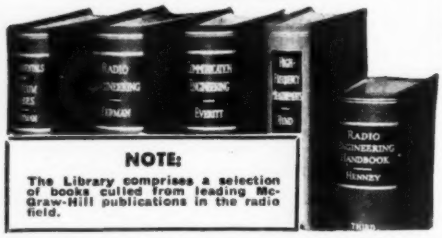

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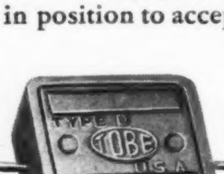
LONG LIFE  **ASSURED**

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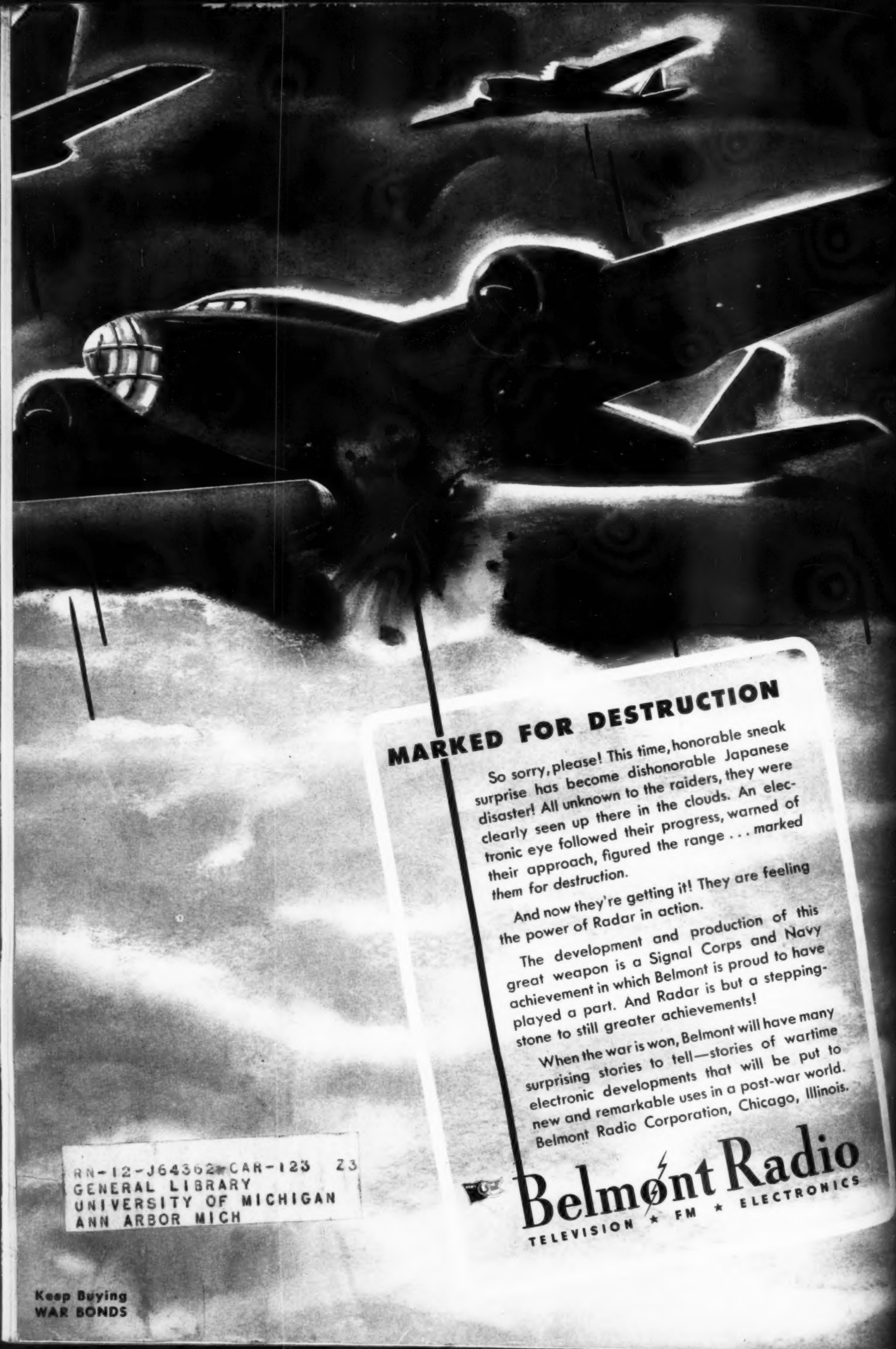
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